

U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

PB-279 409

Houston Urban Plume Study 1974, Description and Data

Texas Univ at Austin Dept of Chemical Engineering

Prepared for

Environmental Sciences Research Lab, Research Triangle Park, N C

Apr 78

TECHNICAL REPORT DATA (Please read Instructions on the reverse before completing)			
1. REPORT NO.	2.	3. RECIPIENT'S ACCESSION NO. PB279409	
4. TITLE AND SUBTITLE HOUSTON URBAN PLUME STUDY - 1974 Description and Data		5. REPORT DATE	
7. AUTHOR(S) James R. Brock		6. PERFORMING ORGANIZATION CODE	
9. PERFORMING ORGANIZATION NAME AND ADDRESS The University of Texas Department of Chemical Engineering Austin, Texas 78712		8. PERFORMING ORGANIZATION REPORT NO.	
12. SPONSORING AGENCY NAME AND ADDRESS Environmental Sciences Research Laboratory - RTP, NC Office of Research and Development U.S. Environmental Protection Agency Research Triangle Park, North Carolina 27711		10. PROGRAM ELEMENT NO. 1AA008	
		11. CONTRACT/GRANT NO. R803660	
15. SUPPLEMENTARY NOTES		13. TYPE OF REPORT AND PERIOD COVERED Final	
		14. SPONSORING AGENCY CODE EPA/600/09	
16. ABSTRACT The 1974 Houston Urban Plume Study (HUPS) was undertaken as a preliminary investigation of some of the unresolved features of Houston's air pollution problem. HUPS was intended specifically to gain limited information on the spatial and temporal distribution of air pollutants--particularly, primary and secondary aerosols--in the Houston area as an aid should a later intensive investigation of aerosol character and transport be needed. Aerial measurements were made of the principal pollutants (SO_2 , NO_x , O_3 , CO , aerosol) of the Houston area. Wind-field measurements were also made. These data were used to estimate pollutant budgets. Values for SO_2 and NO_x (14 metric tons/hr and 40 metric tons/hr, respectively) were reasonably comparable with values derived from emissions inventories of the Texas Air Control Board (13 and 24 metric tons/hr, respectively). On the basis of the limited sampling period, the industrial area (east of downtown Houston) apparently is the major contributor of primary air pollutants in the Houston area. In the morning hours above the mixed layer, relatively large ozone concentrations (max. 0.2 ppm)--almost certainly of photochemical--origin were found that correlated closely with light scattering aerosol, thus indicating the existence above the mixed layer of strong secondary aerosol sources.			
17. KEY WORDS AND DOCUMENT ANALYSIS			
a. DESCRIPTORS		b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
*Air pollution *Aerosols *Sulfur dioxide *Nitrogen oxides *Ozone Plumes *Measurement		*Wind (meteorology) Airplanes *Light scattering Houston, TX	68A 99A
18. DISTRIBUTION STATEMENT RELEASE TO PUBLIC		19. SECURITY CLASS (This Report) UNCLASSIFIED	21. NO. OF PAGES 259
		20. SECURITY CLASS (This page) UNCLASSIFIED	22. PRICE PC A12 MFA 01

BEGIN
FIRST
LINE OF
TEXT
HERE.

TYPING GUIDE SHEET

CENTER
OF PAGE

PB 279 409

TOP OF
IMAGE
AREA

EPA-600/3-78-048b
April 1978

DROPPED
HEAD:
BEGIN
SECTIONS
HERE

HOUSTON URBAN PLUME STUDY - 1974
Description and Data

by

James R. Brock
The University of Texas
Austin, Texas 78712

6-1/2"

9-1/8"

Grant No. R803660

Project Officer

Jack L. Durham
Atmospheric Chemistry and Physics Division
Environmental Sciences Research Laboratory
Research Triangle Park, North Carolina 27711

BEGIN
LAST LINE
OF TEXT

ENVIRONMENTAL SCIENCES RESEARCH LABORATORY
OFFICE OF RESEARCH AND DEVELOPMENT
U.S. ENVIRONMENTAL PROTECTION AGENCY
RESEARCH TRIANGLE PARK, NORTH CAROLINA 27711

BOTTOM OF
IMAGE AREA.
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUS-
TRATIONS

3/8"

REPRODUCED BY
**NATIONAL TECHNICAL
INFORMATION SERVICE**

U.S. DEPARTMENT OF COMMERCE
SPRINGFIELD, VA. 22161

DISCLAIMER

This report has been reviewed by the Environmental Sciences Research Laboratory, U.S. Environmental Protection Agency, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the U.S. Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

BEG'N
FIRST
LINE OF
TEXT
HERE

TYPING GUIDE SHEET

CENTER
OF PAGE

TOP OF
IMAGE
AREA

DROPPED
HEAD:
BEGIN
SECTIONS
HERE

ABSTRACT

The 1974 Houston Urban Plume Study (HUPS) was undertaken as a preliminary investigation of some of the unresolved features of Houston's air pollution problem. HUPS was intended specifically to gain limited information on the spatial and temporal distribution of air pollutants--particularly, primary and secondary aerosols--in the Houston area as an aid should a later intensive investigation of aerosol character and transport be needed.

Aerial measurements were made of the principal pollutants (SO_2 , NO_x , O_3 , CO, aerosol) of the Houston area. Wind-field measurements were also made. These data were used to estimate pollutant budgets. Values for SO_2 and NO_x (14 metric tons/hr and 40 metric tons/hr, respectively) were reasonably comparable with values derived from emissions inventories of the Texas Air Control Board (13 and 24 metric tons/hr, respectively). On the basis of the limited sampling period, the industrial area (east of downtown Houston) apparently is the major contributor of primary air pollutants in the Houston area. In the morning hours above the mixed layer, relatively large ozone concentrations (max. 0.2 ppm)--almost certainly of photochemical origin--were found that correlated closely with light scattering aerosol, thus indicating the existence above the mixed layer of strong secondary aerosol sources.

This report was submitted in partial fulfillment of Grant No. R803660 by the University of Texas, Austin, under the sponsorship of the Environmental Protection Agency. This work covers the period May 1974 to March 1976. The work was completed as of March 31, 1976.

BEGIN
LAST LINE
OF TEXT

3/8"

iii

PAGE NUMBER

BOTTOM OF
IMAGE AREA,
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUSTRATIONS

BEGIN
FIRST
LINE OF
TEXT
HERE

TYPING GUIDE SHEET

CENTER
OF PAGE

TOP OF
IMAGE
AREA

DROPPED
HEAD;
BEGIN
SECTIONS
HERE

CONTENTS

Abstract	iii
Figure	vi
Table	vi
Acknowledgment	vii
1. Introduction	1
2. Conclusions and Recommendations	4
3. Procedure	6
Meteorological information and data	6
Airborne air pollution measurements	8
Ground based air pollution measurements	8
4. Results	10
Summary data	10
Meteorological data	13
Aircraft measurement data	13
5. Discussion	16
Pollutant budgets for Houston area	16
Additional observations	17
6. Summary and Conclusions	22
References	23
Appendices	
A. Real Time Aircraft Data	24
B. Data for Airborne Hydrocarbon Bag Samples	225
C. Airborne Particulate Filter Sample Analysis	227
D. Airborne Particle Size Distribution Measurements	232

BEGIN
LAST LINE
OF TEXT

Preceding page blank

BOTTOM OF
IMAGE AREA
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUSTRATIONS

FIGURES

<u>Number</u>		<u>Page</u>
1	The regions studied by instrumented aircraft and pibal measurements in 1974 Houston Urban Plume Study.....	3
2	Positions of six pilot balloon stations and TACB monitoring stations during 1974 Houston Urban Plume Study.....	7
3	Locations of traverses and spirals of instrumented MRI aircraft during 1974 Houston Urban Plume Study.....	11
4	Fluxes in metric tons/hr-km ² calculated from aircraft data of July 19 and 20, 1974 during 1974 Houston Urban Plume Study.....	18

TABLE

1	Pollutant transport through cross sections for Houston area calculated from aircraft data, 1974 Houston Urban Plume Study, metric tons/hr.....	19
---	--	----

ACKNOWLEDGMENTS

This study was made possible through the support of the Atmospheric Aerosol Research Section, Environmental Sciences Research Laboratory, U.S. Environmental Protection Agency. The cooperation of the U.S. Air Force Air Weather Service, Texas Air Control Board, Meteorological Research Incorporated, National Weather Service, Federal Aviation Administration, University of Texas School of Public Health, The University of Texas at Austin, and Texas A&M University is gratefully acknowledged.

SECTION 1

INTRODUCTION

The City of Houston is situated on the coastal plains of Texas close to the western section of the Gulf of Mexico. Large land masses extend for great distances in every direction from Houston except toward the southeastern quadrant in which lies the Gulf of Mexico. The proximity of the city to the Gulf leads to a local climate with some maritime characteristics, while, at the same time, the adjacent vast expanse of land gives rise to some continental characteristics. The meteorology is, therefore, subject to such variation depending on the large scale wind pattern prevailing at a given moment.

Typically, in the winter months the climate of the Houston area takes on a continental character owing to penetration of polar air masses. In summertime, the area normally experiences a nearly tropical weather regime with very few frontal passages, high relative humidities, and convective rain showers.

The air pollution potential for the Houston area is low owing to strong thermal mixing and to almost continuous low level winds. The ventilating effect of these winds usually provides good dilution of air pollutants. Long periods of air stagnation are not too common, although frequent periods of short duration (one day or so) do occur. Most commonly, these periods of atmospheric stability are associated with surface-based, radiation-type inversions, although occasionally this low-level stability is caused or reinforced by the advection of cool air from the Gulf of Mexico.

The low air pollution potential for the Houston area is fortunate in view of the area's large pollutant sources. Along the Houston Ship Channel, immediately to the east of the downtown area, lies one of the world's greatest concentration of petrochemical and related process industries. Along the Gulf Coast, centered around Houston some 40% of the nation's basic petrochemicals are produced. In addition, in terms of population the Houston area is one of the fastest growing in the country with a metropolitan population of 1,677,863 in 1970. The city has more single family homes and fewer apartments than other cities of comparable size and boasts a high figure for registered motor vehicles (1,521,245 in 1975 for Harris County).

Along with the low air pollution potential, the area has benefited from the use of natural gas, a clean fuel, as its principal energy source. As this fuel increases in price, becomes depleted, or both, substitution of other fuels will occur and it is possible that this advantage in maintaining air quality may diminish.

In brief, the low air pollution potential for the Houston area is offset by relatively large sources of air pollutants. As a result, Houston usually exceeds (with year to year exceptions) the national standards for carbon monoxide (highest hourly values), total suspended particulate matter (highest daily values), ozone (highest hourly values), and non-methane hydrocarbons (highest values for 6-9 a.m.). In addition, the Houston area is marked by persistent haze conditions caused by light scattering aerosol and the area may act as a source of oxidants and other air pollutants which could produce damage to the peanut, soybean, rice, and other important crops in the coastal region.

Much of what is known of the air pollution problem in the Houston area is based on routine surface monitoring stations operated by the Texas Air Control Board and the City of Houston and on emissions inventories compiled by the Texas Air Control Board. As valuable as such information is, it has left unresolved a number of questions concerning Houston's air pollution - notably, the sources of Houston's oxidant problem and the Houston haze.

The 1974 Houston Urban Plume Study (HUPS) was undertaken by the Atmospheric Aerosol Research Section, Environmental Sciences Research Laboratory, USEPA as a preliminary investigation of some of the unresolved features of Houston's air pollution problem. HUPS was intended specifically to gain limited information on the spatial and temporal distribution of air pollutants - particularly, primary and secondary aerosols - in the Houston area as an aid should a later intensive investigation of aerosol character and transport be needed. The regions studied are indicated in Figure 1.

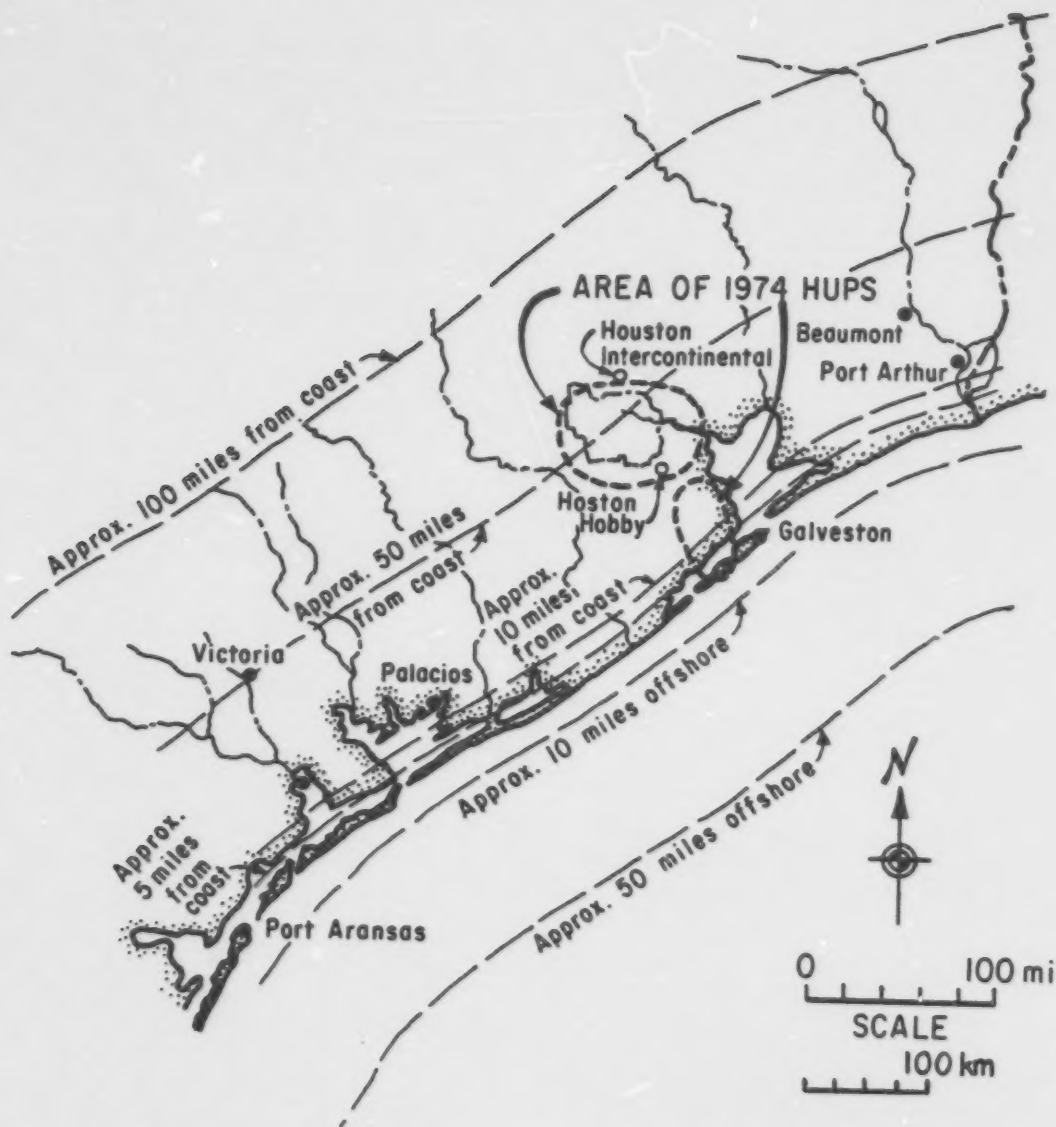


Figure 1. The regions studied by instrumented aircraft and pibal measurements in the 1974 Houston Urban Plume Study.

SECTION 2

CONCLUSIONS AND RECOMMENDATIONS

The 1974 Houston Urban Plume Study (15-24 July, 1974) had as its objective a preliminary investigation of some of the unresolved features of Houston's air pollution problem. The principal tool in this investigation was an instrumented fixed wing aircraft. The following conclusions derived from the study are based on limited data representing seven days (18-24 July, 1974) of actual operation.

(1) Pollutant budgets for the Houston area for SO_2 and NO_x (14 metric tons/hr and 40 metric tons/hr, respectively) were found to be in reasonable comparison with values derived from emissions inventories of the Texas Air Control Board (13 and 24 metric tons/hr, respectively).

(2) On the basis of the limited sampling period, it appears that the industrial area (east of downtown Houston) is the major contributor of primary air pollutants in the Houston area.

(3) During the period of the study, in the morning hours above the mixed layer, relatively large ozone concentrations (max. 0.2 ppm) - almost certainly of photochemical origin - were found which were correlated closely with light scattering aerosol. This correlation indicated the existence above the mixed layer of strong secondary aerosol sources, possibly associated with the oxidation of SO_2 .

This preliminary study has served to indicate more clearly what additional studies are needed to delineate the aerosol character and transport in the Houston area. The most important recommendations are:

(1) Future field studies in the Houston area should be preceded, planned, and carried out adaptively with an adequate air pollution model for the Houston area.

(2) These studies should integrate ground based and aircraft measurements, preferably involving two or more aircraft. At least one helicopter would be desirable to permit sampling below 1000 feet (304.8 m.) owing to frequent low level nighttime inversions in the Houston area.

(3) The studies should be of sufficient duration to permit an adequate sampling of meteorological conditions and diurnal and seasonal variations.

(4) Special attention should be given to characterization of primary sources and background values for the principal air pollutants - particularly for particulate matter.

(5) The test of an adequate delineation of the aerosol transport and character for the Houston area can only be in the form of predictive success of an air pollution model developed previously and adapted extensively from field results.

It is safe to say that studies in the Houston area which proceed without these elements cannot be decisive in resolving the nature of Houston's air pollution problem.

SECTION 3

PROCEDURE

The 1974 Houston Urban Plume Study (HUPS) covered the ten day period 15-24 July. The major elements of the study were a fixed wing aircraft instrumented to measure concentrations of the principal air pollutants and six pilot balloon stations to provide hourly data on wind speed and direction in Houston's atmosphere. These elements were intended to supply information on the spatial and temporal distribution and fluxes of the principal air pollutants.

The following description gives detail on these major elements and list as well auxiliary elements of HUPS.

METEOROLOGICAL INFORMATION AND DATA

(a) Meteorological forecasting and analysis were provided to HUPS by Dr. Gale F. Hoffnagle, INTERA Environmental Consultants, Ltd., Houston, Texas.

(b) Six single theodolite pilot balloon stations were operated by personnel of the U. S. Air Force, Air Weather Service, 6th Mobile Weather Squadron, Tinker A.F.B. with the assistance of students from Texas A&M University, University of Texas School of Public Health, and North Carolina State University.

The positions of these six pilot balloon (pibal) stations during much of the study (the position of one was shifted occasionally) are indicated on the map, Figure 2.

(c) Important meteorological support was furnished by several agencies. Mr. Ervin Vollbrecht and Mr. William Cope of the National Weather Service, Houston office, made available facilities in collection of rawinsonde data and their forecasting skills. Forecasting assistance was also provided by the Texas Air Control Board, Meteorological Section - particularly Mr. Rollie Schroder. Additional surface wind data were furnished by the Houston Lighting and Power Co. and from a recently installed ambient air quality network made available by Mr. Tim Oujezdaky of the Environmental Protection Agency.

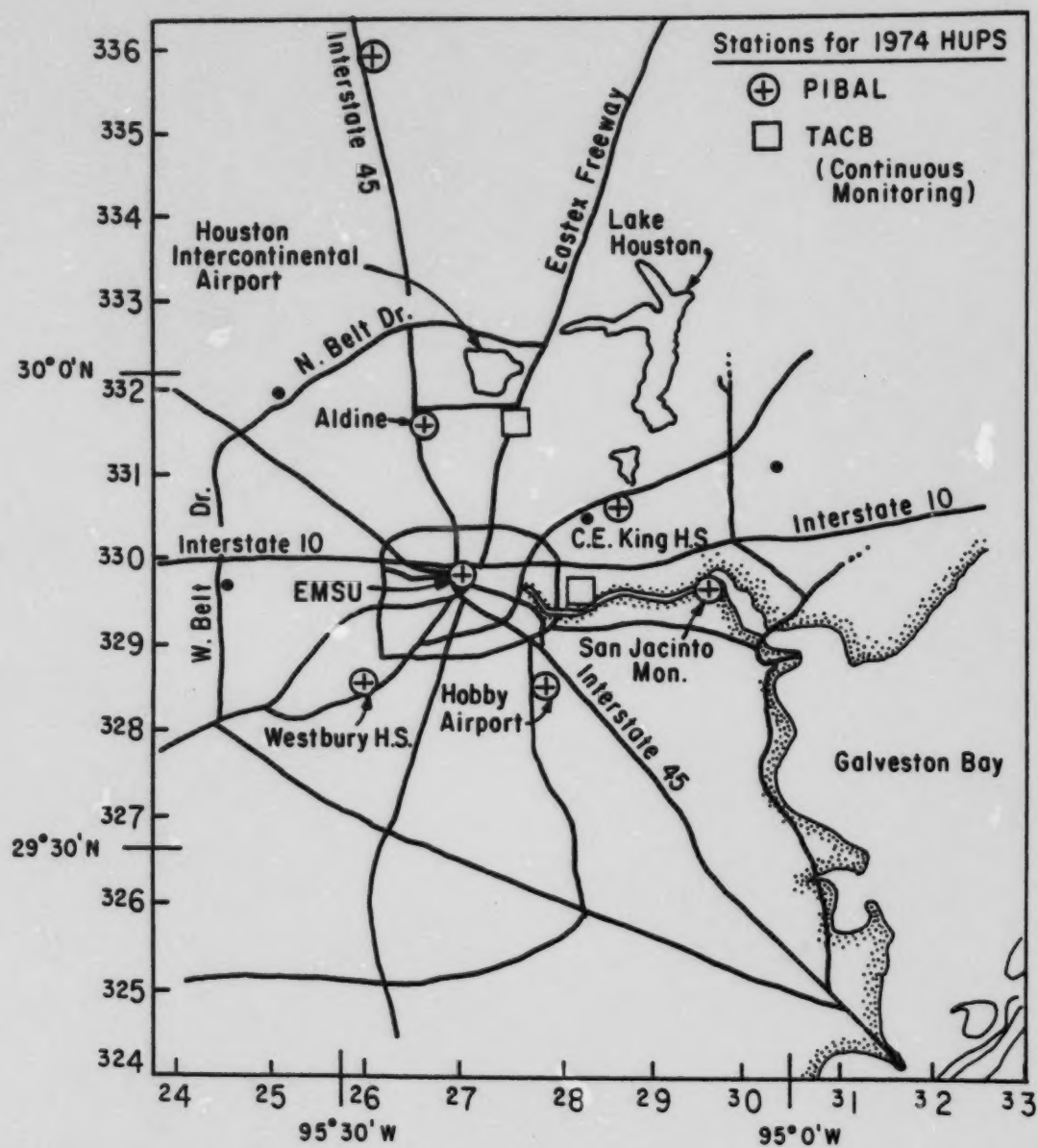


Figure 2. Positions of six pilot balloon stations and TACB monitoring stations during the 1974 Houston Urban Plume Study.

AIRBORNE AIR POLLUTION MEASUREMENTS

(a) The principal air pollutants were measured by means of an instrumented Cessna 206 with Robertson STOL modification and a belly pod. This aircraft operated out of Hobby Airport indicated in Figure 2. The following measurements were obtained by the aircraft.

Condensation Nuclei - Environment 1 Condensation Nuclei Counter

Bscat - MRI Integrating Nephelometer

Carbon Monoxide - Andros 7000 CO Monitor

Hydrocarbon - TEDLAR Bag samples analyzed with a Loenco gas chromatograph using flame ionization detection

Nitric Oxide-Nitrogen Dioxide - Monitor Labs NO-NO₂ Monitor

Ozone - REM Ozone Monitor

Sulfur Dioxide - Theta Sensor

Particle Size Distribution - Minnesota Aerosol Analyzer System

Particle Filter Samples - membrane and glass fiber filters

Temperature, Relative Humidity, Air Speed, Altitude,

Turbulence - A.I.P. Sensors

Data from on-board sensors were acquired by magnetic tape data logger. Calibration of the pollutant gas sensors was provided by the Texas Air Control Board.

(b) It was determined that for purposes of this preliminary study, the aircraft would fly a pattern designed to determine pollutant concentrations at a cross section approximately normal to wind direction. This mode of operation was designed to make possible calculation of pollutant fluxes at the cross section. Flight patterns were to consist of "traverses" and "spirals" in the cross section. A single "traverse" consists of flight in the cross section at a fixed altitude between two specified points on the ground. A single "spiral" consists of a spiral flight path located in a cross section beginning (usually) at maximum altitude and descending to lowest altitude possible around a fixed point on the ground.

GROUND BASED AIR POLLUTION MEASUREMENTS

The principal sources of ground based measurements of air pollutants were the two atmospheric monitoring stations of the Texas Air Control Board (TACB) located in Aldine and Mae Drive as indicated in Figure 2. These stations provide hourly data for the pollutants measured by the aircraft and so are useful for correlation with the aircraft data. A number of gas bubbler samples and high volume particulate sampling stations are in

the Houston area, but these data represent relatively long time averages which are not useful for correlation with the aircraft data.

During the period of the aircraft flights, a seven-channel solar radiometer was operated under the direction of Prof. Richard K. Severs of The University of Texas School of Public Health. Optical depth per channel calculations were performed by NASA-JSC.

SECTION 4

RESULTS

This section presents the data obtained in the 1974 Houston Urban Plume Study (HUPS). First a summary record is presented of the daily activities of the study together with rationale for the measurement program for each day. The section concludes with a presentation of the principal data components: meteorological data, aircraft measurement data, and ground based measurement data.

SUMMARY DATA

Monday, 15 July 1974 - First day of HUPS devoted to installation of pilot balloon crews, checking out instrumentation on MRI aircraft and planning procedures for next day. MRI aircraft had not been fitted with aerosol size distribution measurement system and personnel at University of Minnesota were contacted. Based on meteorological forecast, an urban plume study was set for the next day west of Houston.

Tuesday, 16 July 1974 - MRI aircraft took off at 10:18 a.m. and returned at 12:30 p.m. Plume study to west of Houston attempted. Winds light and variable with visibility aloft (above 300 m.) less than 3 km. Isothermal conditions to 200 m. and near neutral above. Visibility degraded drastically in afternoon to the extent that MRI aircraft could not be operated. A severe air stagnation was announced by local authorities. Data of morning flight lost owing to malfunction of MRI data acquisition system. No plans for aircraft flights for next day owing to prediction of heavy precipitation.

Wednesday, 17 July 1974 - Heavy precipitation in Houston area owing to low in Gulf of Mexico. Day devoted to instrument calibration and maintenance. Afternoon flight tentatively planned for next day.

Thursday, 18 July 1974 - Morning cloudy with only very shallow surface inversion. MRI aircraft took off at 1230 hours CDT for afternoon plume survey. Traverses and spirals flown for cross sections G+I and J+I (see Figure 3). Winds from southeast quadrant. Aircraft data successfully acquired. Morning flight planned for next day.

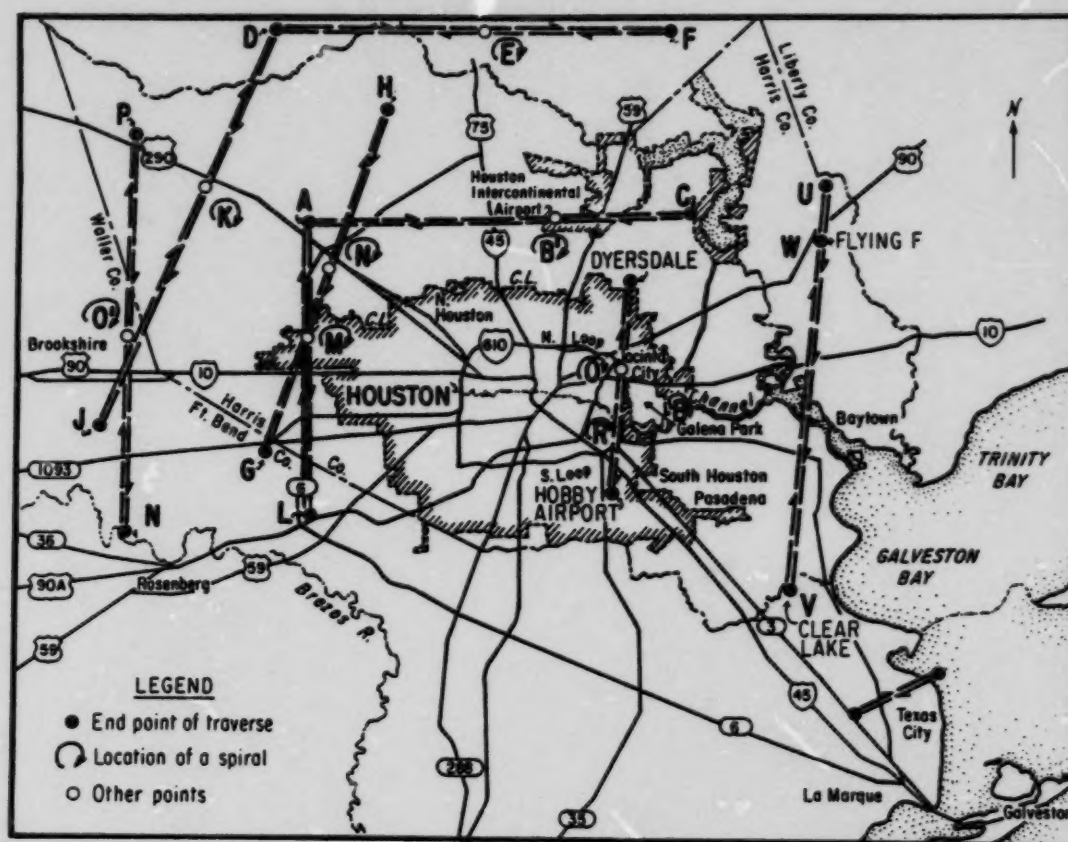


Figure 3. Locations of traverses and spirals of instrumented MRI aircraft during the 1974 Houston Urban Plume Study.

Friday, 19 July 1974 - Winds from southwest to west weakening in afternoon. MRI aircraft took off at 0900 hours CDT. Flew cross section L→A (see Figure 3). Afternoon spent setting up particle size analysis system. Flight planned for next morning.

Saturday, 20 July 1974 - Westerly winds. MRI aircraft took off at 0800 hours CDT. Flew cross section L→A, downwind traverse M→Q, cross section Clear Lake - Flying F→ (CL→FF), and cross section Hobby-Dyers (H→D). Particle size analysis system not yet installed. All other data successfully acquired. Aircraft returned to base at 1200 hours CDT. Aircraft took off for afternoon run at 1330 hours CDT. Flew cross sections H→D, CL→FF. Data successfully acquired.

Sunday, 21 July 1974 - Westerly winds. MRI aircraft took off at 0600 hours CDT. Flew cross sections H→D, CL→FF. Aircraft returned to base 0900 hours CDT. Particle size analysis system still not operational. All other data successfully acquired. Particle size analysis system installed Sunday afternoon.

Monday, 22 July 1974 - Westerly winds. MRI aircraft took off at 0700 hours CDT. Flew cross sections H→D, CL→FF. Aircraft returned to base at 1000 hours CDT. Particle size distribution data acquired. All other data successfully acquired. Aircraft took off at 1400 hours CDT. NO-NO_x inoperative due to blown power supply. Aircraft unsuccessfully attempted to fly "wind drift"* pattern over the Houston Ship Channel. Increasing southerly wind component. Several pollutant sensors inoperative and data system inoperative. Only particle size distributions obtained.

Tuesday, 23 July 1974 - Day spent in repair and calibration of instruments.

Wednesday, 24 July 1974 - Westerly winds. Aircraft took off at 0900 hours CDT. Morning spent in obtaining particle filter samples, particle size distributions, and hydrocarbon bag samples over Houston Ship Channel. Aircraft took off for afternoon run at 1500 hours CDT. Flew to Galveston Island and performed spiral over the Gulf of Mexico from 10,000' to 200'. Then flew East to West heading north of Texas City to obtain cross section measurements I-II. Aircraft returned to base at 1730 hours CDT. All data successfully acquired. Final meeting of participants terminating HUPS held in evening.

*A "wind drift" pattern refers to a mode of flight in which the only component of the velocity of the aircraft in the direction of the wind is that due to the wind.

METEOROLOGICAL DATA

All measured meteorological data for the 1974 Houston Urban Plume Study have been presented in a separate report by Dr. Gale F. Hoffnagle (1). These data will not be reproduced in this report. Data obtained include surface anemometer data, pilot balloon soundings up to approximately 4000 feet altitude, rawinsonde soundings from the National Weather Service, and National Weather Service national weather plots.

From the conclusions of Dr. Hoffnagle's report (1), the following are some of the important features of the meteorological data as they apply to HUPS.

(a) The period of HUPS represents an unusual meteorological situation. A strong and persistent high over Arkansas prevented normal weather systems from penetrating to the Houston area.

(b) This high allowed a mesoscale pattern of consistent and strong westerly to southwesterly flow on each successive morning. The mixing layer was, therefore, well ventilated.

(c) Because of opposing flow for low-level (westerly) and upper-level (easterly) winds, most of the mornings experienced a very calm transition zone between 3000 and 5000 feet. Flows in this zone were weak and variable in direction.

As will be evident in the discussion which follows, the persistent westerly lower-level flows which existed for 19, 20, 21, 22 July were extremely fortunate and made possible day-to-day comparisons of pollutant fluxes and separation of the urban and industrial (Houston Ship Channel) contributions to the air pollutant fluxes. Without this persistence, it would not have been possible to obtain pollutant fluxes at comparable cross sections as was done in this study.

AIRCRAFT MEASUREMENT DATA

Table A-1 in Appendix A summarizes all the traverses and spirals flown by the instrumented MRI aircraft during the 1974 Houston Urban Plume Study (HUPS). The first column in Table A-1 is the identification number (4 or 5 digits) which appears on the computer plots for each pollutant concentration (or other measure). The second column gives date of the run and the third and fourth columns give the times, respectively, for beginning and ending a particular traverse or spiral. The fifth column identifies the beginning and ending surface points for a traverse or, in the case of spirals, the location of the surface point for the spiral. The sixth column gives for a particular

traverse the altitude in feet of the aircraft. The locations of all the surface points are indicated in Figure 3.

In Appendix A are assembled, according to the code in Table A-1, computer plots of all the real time data acquired by the instrumented MRI aircraft during HUPS. The information in Table A-1 is reproduced for each plot sequence which comprises the data for b_{scat} , condensation nuclei concentration, CO, O₃, NO, NO_x, SO₂, temperature, and relative humidity.

Airborne Hydrocarbon Bag Samples

In Appendix B are found the data for ambient hydrocarbon concentrations. Hydrocarbon samples were collected in Tedlar bags, the usual procedure being to fill a bag during a given traverse or spiral. Subsequently, the bag samples were analyzed by means of a Loenco gas chromatograph.

Airborne Particulate Filter Data

Two types of particulate filter samples were collected in the air: glass fiber filter samples for subsequent sulfate analysis and membrane filters for subsequent microscopic examination.

The glass fiber filter samples were obtained in the usual manner when sampling for particulate sulfate - namely, two filters, suitably treated to reduce their effect in oxidizing gaseous SO₂, are employed in series. The first filter is designed to collect particulate sulfate; the second filter similarly treated serves as a reference for the extent of conversion of SO₂ to sulfate on the first filter. Unfortunately, ambient conditions were such that in all samples, sulfate on the first filter was found to be only 7-35% higher than the second, backup, filter. Thus, the reliability of the data are questionable. These data are, therefore, omitted from this report.

Aerosol samples were collected on 0.8 μm Millipore filters on 19, 20, 21 July 1974, using the MRI aircraft sampling systems. The prevailing westerly winds were the same on all the sampling days and during all sampling runs. These samples were analyzed by optical and electron microscopy by Drs. R. Draftz and J. Graf of I.I.T.R.I. The results of their investigation are discussed in the next section and are presented in Appendix C.

Airborne Particle Size Distribution Measurements

Particle size distributions were determined using the airborne particle size analysis system which consists of a Royco optical particle counter and a TSI Aerosol Mobility Analyzer.

Calibration values for converting the field readings to particle size distributions were provided by Dr. Bruce Cantrell of the University of Minnesota. It must be pointed out that the measurement of the particle size distribution by this system is not in real time; a bag is filled over some period of time, typically of the order of a minute and the bag sample requires of the order of two minutes to be run by the system. The measurements are, therefore, averages over some unspecified volume and are subject to inaccuracies owing to those introduced by bag sampling and to those inherent in the system itself. The errors introduced thereby, will generally serve to give values for particle concentrations which are lower than the ambient values. The data for particle size distribution are presented in Appendix D as plots of particle volume density, $dV/d\log D$, in units of $\mu\text{m}^3/\text{cc}$ as a function of particle diameter in μm . The signals from particle size analysis system were fed into the MRI data logging system. In some cases, flags were missing so that some measurements corresponded to samples collected at locations not precisely known. An index at the front of Appendix D is given for all the subsequent figures.

SECTION 5

DISCUSSION

During the period of HUPS a strong and persistent high over Arkansas allowed a mesoscale pattern of consistent and strong westerly to southwesterly flow on each successive morning extending up to approximately 1300 meters. These persistent lower level flows which existed for 19-22 July 1974 made possible day-to-day comparisons of pollutant fluxes and the separation of the urban and industrial (Houston Ship Channel) contributions to the air pollution fluxes.

Also an important qualitative observation was derived from the real time aircraft data. This was the occurrence above 300 meters altitude during the morning hours of closely correlated layers of light scattering aerosol and ozone approximately 500 meters thick. Maximum ozone concentration in these layers was of the order of 0.2 ppm. These layers appeared to exist on each morning during HUPS and apparently extended over the entire Houston area.

POLLUTANT BUDGETS FOR HOUSTON AREA

In addition to information on the evolution of the Houston haze aerosol, the principal result of HUPS is the calculation of pollutant budgets for the Houston area from the aircraft data. These calculations were performed for three cross sections which were approximately perpendicular to the lower westerly flows during the period 19-22 July 1974. Starting from west of downtown Houston these cross sections were as follows (please refer to Figure 3): (a) L→A, a plane perpendicular to the surface extending from Sugar Land on the south to a point immediately west of the Flying Acres Ranch on the north up to an altitude of approximately 1200 meters. (b) H→D, a plane perpendicular to the surface extending from Hobby Airport on the south to Dyersdale on the north up to an altitude of approximately 1200 meters. (c) CL→FF, a plane perpendicular to the surface extending from Clear Lake on the south up to Flying F Ranch on the north (a distance of 47 km) up to an altitude of approximately 1200 meters. Pollutant fluxes were calculated in each of these cross sections.

These fluxes are shown in metric tons/hr-km² in Figure 4 in a pictorial fashion. The westerly winds are indicated as being perpendicular to the three cross sections; actually, the winds deviated from a direction of 270°. The wind velocity component normal to the cross sections was always employed in the flux calculations. Pibal data for the study period are given in Ref. (1) In Tables I-47 of Ref. (1), the last row entry of CONROE for Pibal launch site should read San Jacinto Monument.

These pollutant fluxes were used to estimate pollutant budgets for the areas between cross sections L→A to H→D and H→D to CL→FF. It was determined from the aircraft measurements that the plane CL→FF included the pollutant plumes of Houston and the industrial area along the Houston Ship Channel. Total pollutant transport rates for the Houston area are presented in Table 1. Also budget values for the Houston area were calculated by subtracting the background values for L→A from the CL→FF values. These values for SO₂ (14 metric tons/hr) and NO_x (40 metric tons/hr) are found to compare reasonably well with the values derived from emissions inventories of the Texas Air Control Board for 1974 (13 and 24 metric tons/hr, respectively).

Suspended particulate matter fluxes and budgets were estimated using an empirical correlation (2) between light scattering coefficient b_{scat} and particle mass concentration:

$$\text{Particulate mass concentration } (\mu\text{g}/\text{m}^3) = 38 b_{\text{scat}} (10^{-4}\text{m}^{-1}).$$

It is not possible to assess the accuracy of this correlation for the conditions of HUPS.

The flux and budget values for CO appear to be unreasonable. Examination of the CO data for aircraft measurements in the spiral mode indicate that the CO sensor was probably malfunctioning during all the aircraft measurements; the reason for this malfunction is unknown.

ADDITIONAL OBSERVATIONS

A number of important qualitative observations were derived from the real time aircraft data.

One of these was the occurrence above 300 meters altitude during the morning hours of closely correlated layers of light scattering aerosol and ozone. These layers were approximately 500 m. thick and were found over the entire region of the HUPS study. Maximum ozone concentration in these layers was of the order of 0.2 ppm.

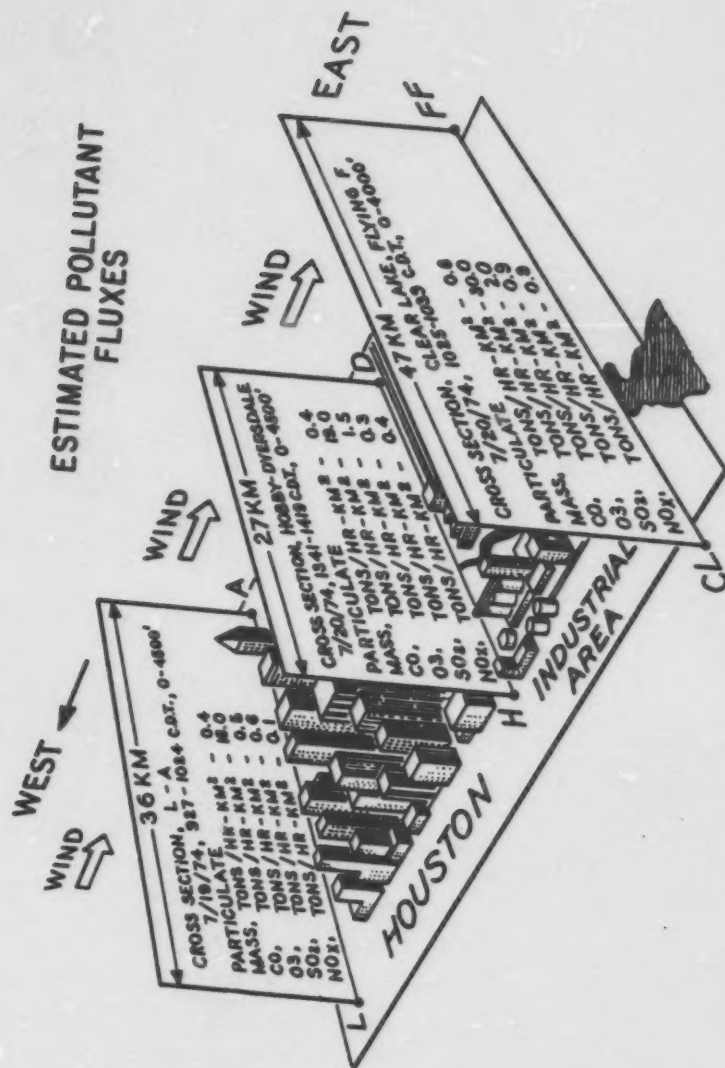


Figure 4. Fluxes of pollutants in metric tons/hr-km² calculated from aircraft data of July 19 and 20, 1974 during the 1974 Houston Urban Plume Study. 1 foot = 0.3048 meters.

TABLE 1. POLLUTANT TRANSPORT THROUGH CROSS SECTIONS FOR HOUSTON
AREA CALCULATED FROM AIRCRAFT DATA, 1974 HOUSTON URBAN
PLUME STUDY, METRIC TONS/HR

Cross Section	Suspended Particulate Matter*	CO	SO ₂	O ₃	NO _x
L A	22	950	32	26	5
Area: (5.5 km south of Sugar Land to 5.5 km north of Flying Acres Ranch X 1200 meters altitude)					
Date and Time: 7/19/74, 0927-1024 CDT					
H D	21	960	22	54	15
Area: (10 km south of Hobby Airport to 10 km north of Dyersdale X 1200 meters altitude)					
Date and Time: 7/20/74, 1341-1419 CDT					
CL FF	42	1500	46	88	45
Area: (Clear Lake to Flying F Ranch X 1200 meters altitude)					
Date and Time: 7/20/74, 1025-1039 CDT					

*Calculated from light scattering coefficient.

The relatively large ozone concentrations observed most probably are the result of photochemical reactions; no primary ozone sources of sufficient magnitude to account for these concentrations are known.

The concentration ratios $(NO)(O_3)/(NO_2)$ exceed the steady state value of 0.0209 ppm expected in the presence of only sunlight, O_3 , NO , NO_2 , and air. In fact, values of this ratio ranged from around 0.04 ppm to 0.15 ppm in the ozone layers. This suggests the presence of hydrocarbons and the absence of any primary source input of NO into these layers during the course of the reactions leading to formation of O_3 .

In addition, the close correlation of b_{scat} and O_3 concentrations indicates the existence of secondary aerosol sources in these layers. A possible secondary aerosol source would be that arising from the accelerated oxidation of SO_2 which occurs in the presence of photochemical reactions and involves O_3 and olefinic hydrocarbons. Unfortunately the analysis of particulate filter samples for sulfate was not successful so that there is no direct confirmation of this hypothesis.

Analysis of aerosol samples collected on 0.8 μm Millipore filters by Drs. Draftz and Graf of I.I.T.R.I. showed that feldspars and clay minerals were the predominant types of particles on all the samples. According to Drs. Draftz and Graf, little or no urban (auto exhaust, combustion products) aerosol particles were found in the samples, even in the downwind samples. Samples downwind of maximum industrial activity in the ship channel area were believed to contain very few particles indicative of primary sources of fine particles. In fact, the mineral particle concentrations appeared slightly greater in these samples than in those collected at the west side of Houston.

A few samples contained several clusters of fluffy, carbonaceous deposits. These have not been identified but are not believed to be oil soot, auto emissions, or from coal burning.

The extensive industrial activity in the Houston area and the absence of significant quantities of combustion derived particles suggests possible malfunction of the filter sampling system on the MRI aircraft or sample loss in the process of microscopic analysis. There is ample photographic evidence and evidence from b_{scat} and condensation nuclei counts from the instruments aboard the aircraft showing substantial quantities of fine particles associated with combustion processes. For completeness, the report of the microscopical analyses of the filter samples by Drs. Draftz and Graf of I.I.T.R.I. are given in Appendix C.

Particle size distributions were obtained from data supplied by a system consisting of a TSI Model 3030 electrical aerosol size analyzer and a Royco Optical Particle Counter. The calibrations for converting the raw data were furnished by Dr. B. Cantrell of the University of Minnesota. In a number of cases it is observed that there is a substantial mismatch between the T.S.I. analyzer and the Royco counter in the region of particle size overlap. In addition to these occurrences, there are also questions concerning the biasing and sample loss attributable to the sampling procedure. Added to the suspected difficulties cited for the filter samples, the operation of the airborne aerosol size analysis system required filling a plastic bag with sample which was then retained in the bag for the 2-3 minutes required for acquisition of the data. No satisfactory assessment can be given of the possible inaccuracies introduced through these deficiencies. At best the data may be viewed as providing a qualitative measure of the particle concentration.

Included in the particle size distribution data given in Appendix D is an interesting set of measurements taken during spirals over Hobby Airport. These data represent particle size distributions from ground level to approximately 3000 m. They correlated qualitatively with the seven-channel solar radiometer measurements to be discussed in a separate report.

Unfortunately no filter or bag samples were obtained in the ozone and particulate-rich layers observed in the morning above 300 m. This is one of many instances in which immediate access to data would have been invaluable. In the HUPS study, the aircraft data were not available for study until six to twelve months after the completion of HUPS.

SECTION 6

SUMMARY AND CONCLUSIONS

The 1974 Houston Urban Plume Study was intended specifically to gain limited information on the spatial and temporal distribution of air pollutants - particularly primary and secondary sources of aerosols - in the Houston area as an aid should a later intensive investigation of aerosol character and transport be needed. To this extent the study was successful.

The principal results and conclusions of the study were:

(1) Pollutant budgets were established for the urban and industrial (east of downtown Houston) areas of the Houston area. The budget values for SO_2 and NO_x found by aircraft measurement (14 metric tons/hr and 40 metric tons/hr, respectively) compared reasonably well with values derived from emissions inventories of the Texas Air Control Board (13 and 24 metric tons/hr, respectively).

(2) On the basis of the limited sampling period, it appears that the industrial area (east of downtown Houston) is the major contribution of primary air pollutants in the Houston area (please see Table 1).

(3) During the period of the study, in the morning hours above the mixed layer, relatively large ozone concentrations - almost certainly of photochemical origin - were found which were correlated closely with light scattering aerosol. This correlation indicated the existence above the mixed layer of strong secondary aerosol sources, possibly associated with the oxidation of SO_2 .

Additional work as outlined in the recommendations of Section 2 of this report will be needed to gain an understanding of aerosol character and transport in the Houston area.

REFERENCES

1. Hoffnagle, Gale F. Air Pollution Meteorology During the Houston Urban Plume Study, July 1974. EPA-600/3-77-073, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, 1977. 59 pp.
2. Charlson, R. J., Ahlquist, N. C., Selvidge, H., and MacCreedy, P. B. "Monitoring of Atmospheric Aerosol Parameters with the Integrating Nephelometer". Journal of the Air Pollution Control Association 19:937-942 (1969).

BEGIN
FIRST
LINE OF
TEXT
HERE

TYPING GUIDE SHEET

CENTER
OF PAGE

TOP OF
IMAGE
AREA

DROPPED
HEAD;
BEGIN
SECTIONS
HERE

APPENDIX A

REAL TIME AIRCRAFT DATA

Table A-1 summarizes all the traverses and spirals flown by the instrumented MRI aircraft during the 1974 Houston Urban Plume Study (HUPS). The first column in Table A-1 is the identification number (4 or 5 digits) which appears on the computer plots for each pollutant concentration (or other measure). The second column gives date of the run and the third and fourth columns give the times, respectively, for beginning and ending a particular traverse or spiral. The fifth column identifies the beginning and ending surface points for a traverse or, in the case of spirals, the location of the surface point for the spiral. The sixth column gives for a particular traverse the altitude in feet of the aircraft. The locations of all the surface points are indicated in Figure 3.

In Appendix A are assembled, according to the code in Table A-1, computer plots of all the real time data acquired by the instrumented MRI aircraft during HUPS. The information in Table A-1 is reproduced for each plot sequence which comprises the data for b_{scat} , condensation nuclei concentration, CO, O₃, NO, NO_x, SO₂, temperature, and relative humidity.

BEGIN
LAST LINE
OF TEXT

3/8"

24

PAGE NUMBER

BOTTOM OF
IMAGE AREA
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUS-
TRATIONS

TABLE A-1. INDEX TO PLOTS OF REAL TIME AIRCRAFT DATA

Run Number	Date	Time, LST	Site	Flight Mode
1001	7/18/74	13.57.35 - 14.10.33	Point G to	Point I Traverse
1002	7/18/74	14.15.20 - 14.28.7	Point I to	" "
1003	7/18/74	14.31.30 - 14.43.3	Point G to	" "
2001	7/18/74	15.16.33 - 15.16.33	Point J to	Point D
2002	7/18/74	15.34.59 - 15.52.54	Point D to	Point J
2003	7/18/74	15.55.48 - 16.9.52	Point J to	Point D
3001	7/19/74	9.26.47 - 9.35.48	Point L to	Point A
3002	7/19/74	9.46.33 - 9.56.43	Point A to	Point L
3003	7/19/74	10.1.11 - 10.10.34	Point L to	Point A
3004	7/19/74	10.14.21 - 10.24.7	Point A to	Point L
3005	7/19/74	10.30.47 - 11.10.28	Point L to	Point A
4001	7/20/74	8.27.47 - 8.37.25	Point L to	Point A
5001	7/20/74	9.4.13 - 9.14.43	Point M to	Point Q
6001	7/20/74	10.25.30 - 10.38.48	Flying F to	Clear Lake
6002	7/20/74	10.42.16 - 10.52.3	Clear Lake to	Point W
6003	7/20/74	11.2.45 - 11.15.33	Flying F to	Clear Lake
7001	7/20/74	13.40.34 - 13.50.45	Hobby to	Dyers XSec
7002	7/20/74	13.53.21 - 14.0.12	Dyers XSec to	Hobby
7003	7/20/74	14.2.37 - 14.9.54	Hobby to	Dyers XSec
7004	7/20/74	14.12.10 - 14.18.44	Dyers XSec to	Hobby
8001	7/20/74	14.41.50 - 14.57.10	Clear Lake to	Flying F
8002	7/20/74	14.57.24 - 15.10.38	Flying F to	Clear Lake

(Continued)

TABLE A-1 (Continued)

Run Number	Date	Time, LST	Site	Flight Mode
8003	7/20/74	15.13.57 - 15.27.11	Clear Lake	Flying F
8004	7/20/74	15.29.42 - 15.42.55	Flying F	Clear Lake
9001	7/21/74	6.32.36 - 6.39.12	Hobby	Dyers XSec
9002	7/21/74	6.42.47 - 6.50.21	Dyers XSec	Hobby
9003	7/21/74	6.53.11 - 7.0.26	Hobby	Dyers XSec
9004	7/21/74	7.3.50 - 7.10.54	Dyers XSec	Hobby
10001	7/21/74	7.36.0 - 7.49.31	Clear Lake	Flying F
10002	7/21/74	7.52.21 - 8.6.1	Flying F	Clear Lake
10003	7/21/74	8.9.38 - 8.23.16	Clear Lake	Flying F
10004	7/21/74	8.26.53 - 8.39.42	Flying F	Clear Lake
11001	7/22/74	7.26.39 - 7.33.35	Hobby	Dyers XSec
11002	7/22/74	7.36.51 - 7.44.14	Dyers XSec	Hobby
11003	7/22/74	7.47.27 - 7.54.51	Hobby	Dyers XSec
11004	7/22/74	7.58.37 - 8.5.14	Dyers XSec	Hobby
12001	7/22/74	8.10.30 - 8.17.55	Hobby	Dyers XSec
12002	7/22/74	8.21.18 - 8.28.52	Dyers XSec	Hobby
13001	7/22/74	8.56.15 - 9.10.14	Clear Lake	Flying F
13002	7/22/74	9.13.0 - 9.25.55	Flying F	Clear Lake
13003	7/22/74	9.29.1 - 9.43.44	Clear Lake	Flying F
13004	7/22/74	9.46.33 - 9.58.17	Flying F	Clear Lake
14001	7/24/74	16.28.31 - 16.32.51	Point -I-	Point -II-
14002	7/24/74	16.35.6 - 16.39.41	Point -II-	Point -I-
14003	7/24/74	16.42.38 - 16.46.53	Point -I-	Point -II-

(Continued)

TABLE A-1 (Continued)

Run Number	Date	Time, LST	Site	Flight Mode
20000	7/18/74	13.8.36 - 13.35.58	Hobby	Spiral
21000	7/18/74	14.51.30 - 15.0.24	Point H	"
22000	7/18/74	16.18.39 - 16.26.19	Point K	"
23000	7/18/74	16.51.19 - 17.10.31	Hobby	"
24000	7/19/74	8.45.58 - 9.8.44	Hobby	"
25000	7/19/74	10.59.10 - 11.8.11	Hobby	"
26000	7/20/74	8.51.12 - 9.0.8	Point M	"
27000	7/20/74	9.25.8 - 9.32.59	Turn Basin	"
28000	7/20/74	9.46.11 - 9.54.46	Galena Prk	"
29000	7/20/74	10.6.11 - 10.14.14	Monument	"
30000	7/20/74	13.22.55 - 13.36.16	Hobby	"
31000	7/20/74	13.42.35 - 14.30.27	Turn Basin	"
32000	7/20/74	15.51.44 - 15.59.48	Monument	"
33000	7/21/74	6.10.41 - 6.24.2	Hobby	"
34000	7/21/74	7.15.14 - 7.23.50	Turn Basin	"
35000	7/21/74	8.48.53 - 8.57.2	Monument	"
36000	7/21/74	9.6.39 - 9.14.28	Point Q	"
37000	7/21/74	9.23.14 - 9.33.23	Hobby	"
38000	7/22/74	7.3.19 - 7.18.13	Hobby	"
39000	7/22/74	8.36.44 - 8.44.39	Turn Basin	"
40000	7/22/74	10.6.49 - 10.14.36	Monument	"
41000	7/22/74	10.26.28 - 10.35.58	Hobby	"
42000	7/24/74	9.26.57 - 9.45.26	Hobby	"
43000	7/24/74	9.53.9 - 10.10.59	Hobby	"
44000	7/24/74	14.43.58 - 15.15.38	Galveston	"
45000	7/24/74	15.48.13 - 16.20.33	Texas City	"

BEGIN
FIRST
LINE
TEXT
HERE

TYPING GUIDE SHEET

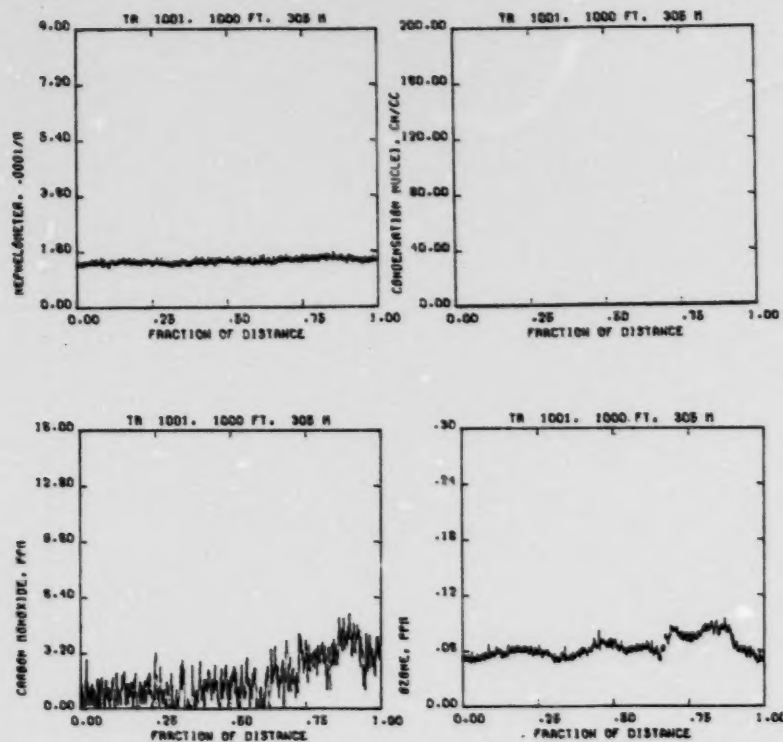
CENTER

TOP OF
IMAGE
AREA

DROPPE
HEAD
BEGIN
SECTION
HERE

TR. 1001. 1000 FT. 305 M. POINTS G TO I

7/18/74. 13.57.35 TO 14.10.33. DISTANCE= 40.4 KM



BEGIN
LAST LINE
OF TEXT

3/8"

28

PAGE NUMBER

EPA-287 (Cin.)
(4-76)

BOTTOM OF
IMAGE AREA
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUS-
TRATIONS

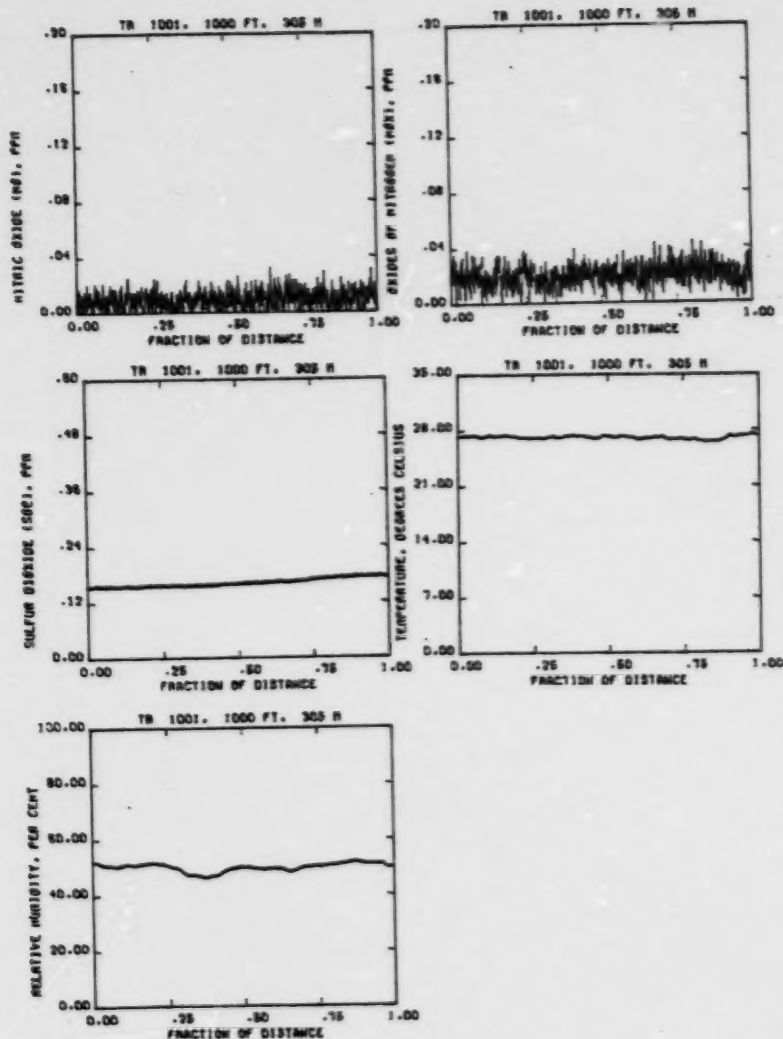
BEGIN
FIRST
LINE OF
TEXT
HERE

TYPING GUIDE SHEET

CENTER
OF PAGE

TOP OF
IMAGE
AREA

DROPPED
HEAD
BEGIN
SECTION
HERE



BEGIN
LAST LINE
OF TEXT

BOTTOM OF
IMAGE AREA
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUS-
TRATIONS

3/8"

BEGIN
FIRST
LINE OF
TEXT
HERE

TYPING GUIDE SHEET

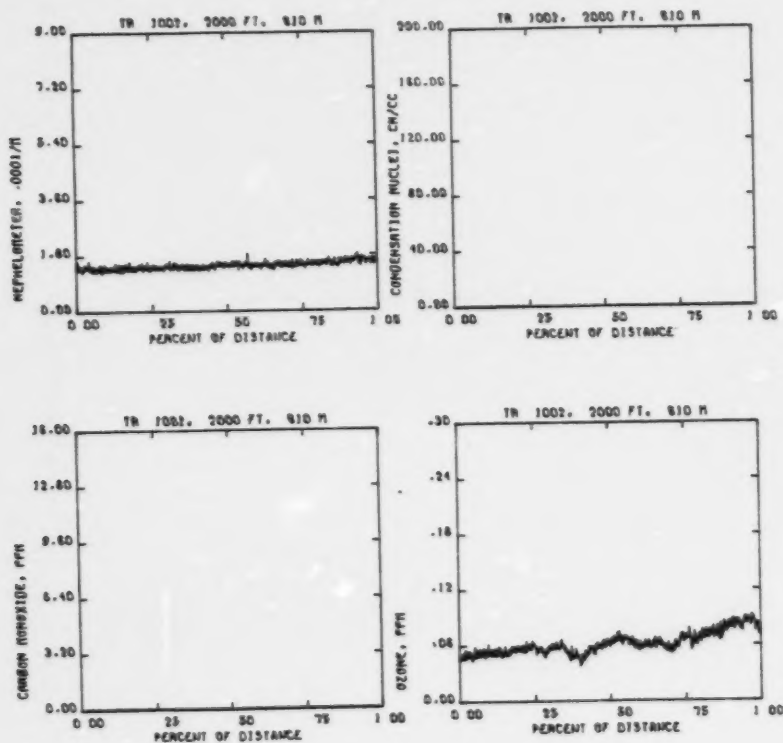
CENTER
OF PAGE

TOP OF
IMAGE
AREA

DROPPED
HEAD
BEGIN
SECTION
HERE

TR. 1002, 2000 FT. 610 M. POINTS 0 TO 1

7/18/74, 14:15:20 TO 14:29: 7, DISTANCE= 40.4 KM



BEGIN
LAST LINE
OF TEXT

3/8"

30

PAGE NUMBER

EPA-287 (Cir.)
(4-76)

BOTTOM OF
IMAGE AREA
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUS-
TRATIONS

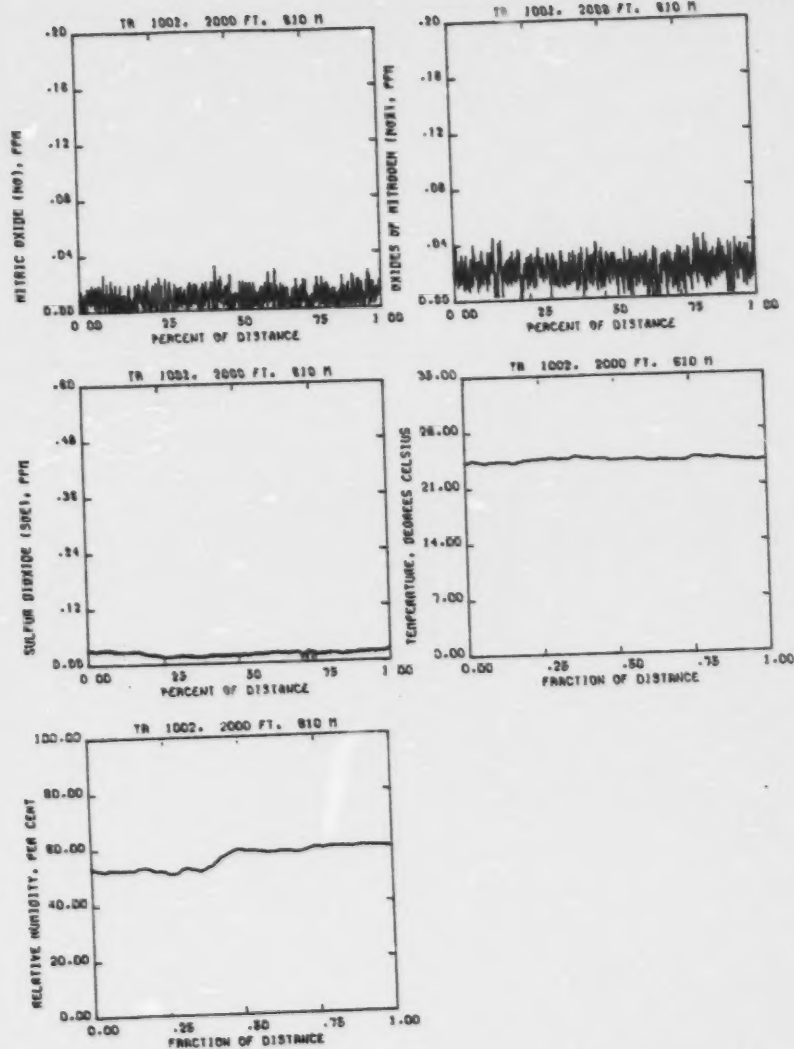
BEGIN
FIRST
LINE OF
TEXT
HERE

TYPING GUIDE SHEET

CENTER
OF PAGE

TOP OF
IMAGE
AREA

DROPPE
HEAD,
BEGIN
SECTIO
HERE



BEGIN
LAST LINE
OF TEXT

3/8"

31

PAGE NUMBER

BOTTOM OF
IMAGE AREA;
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUS-
TRATIONS

BEGIN
FIRST
LINE OF
TEXT
HERE

TYPING GUIDE SHEET

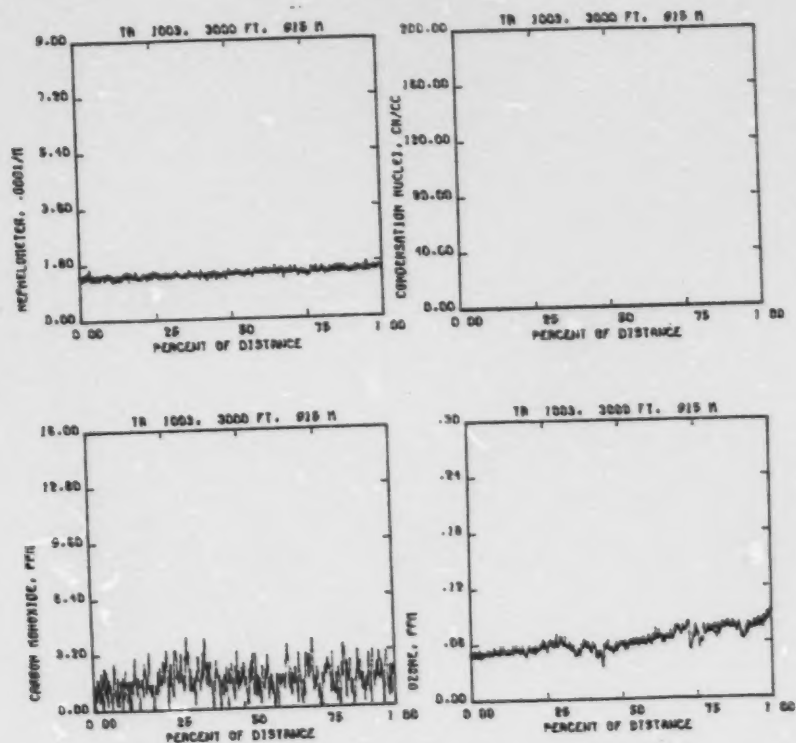
CENTER
OF PAGE

TOP OF
IMAGE
AREA

DROPP
HEAD
BEGIN
SECTION
HERE

TR. 1003. 3000 FT. 915 M. POINTS 0 TO 1

7/18/74. 14:31:30 TO 14:43:30. DISTANCE= 40.4 KM



BEGIN
LAST LINE
OF TEXT

3/8"

32

PAGE NUMBER

BOTTOM OF
IMAGE AREA;
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUS-
TRATIONS

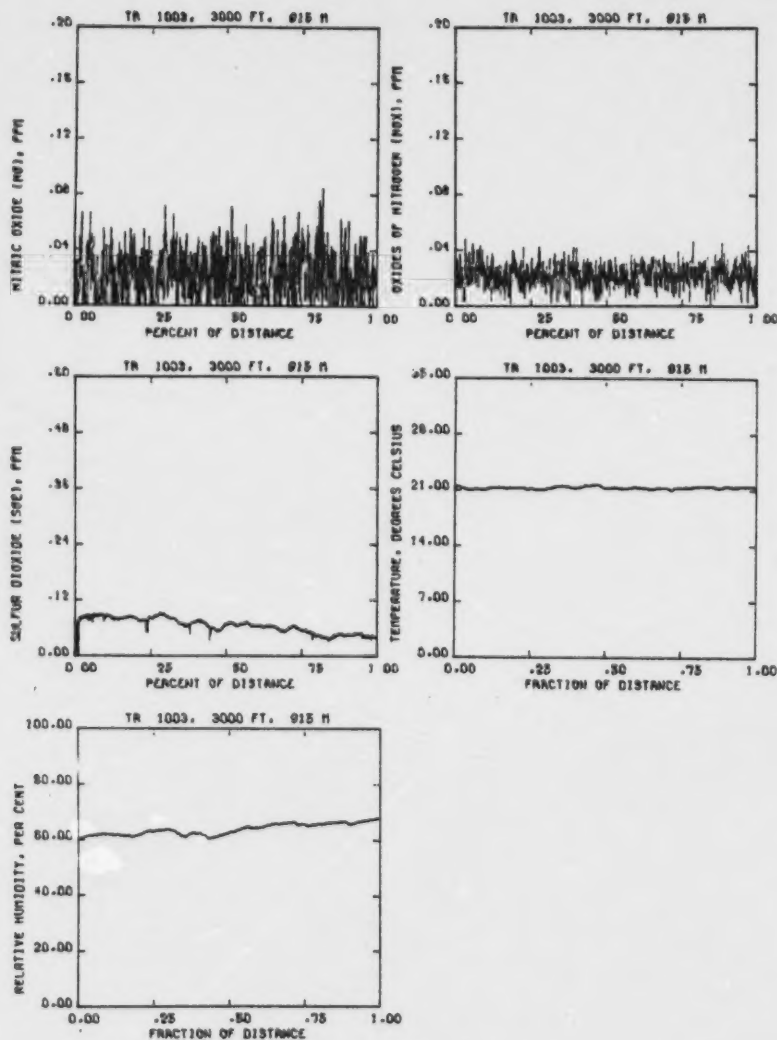
BEGIN
FIRST
LINE OF
TEXT
HERE

TYPING GUIDE SHEET

CENTER
OF PAGE

TOP OF
IMAGE
AREA

DROPPE
HEAD
BEGIN
SECTION
HERE



BEGIN
LAST LINE
OF TEXT

3/8"

33

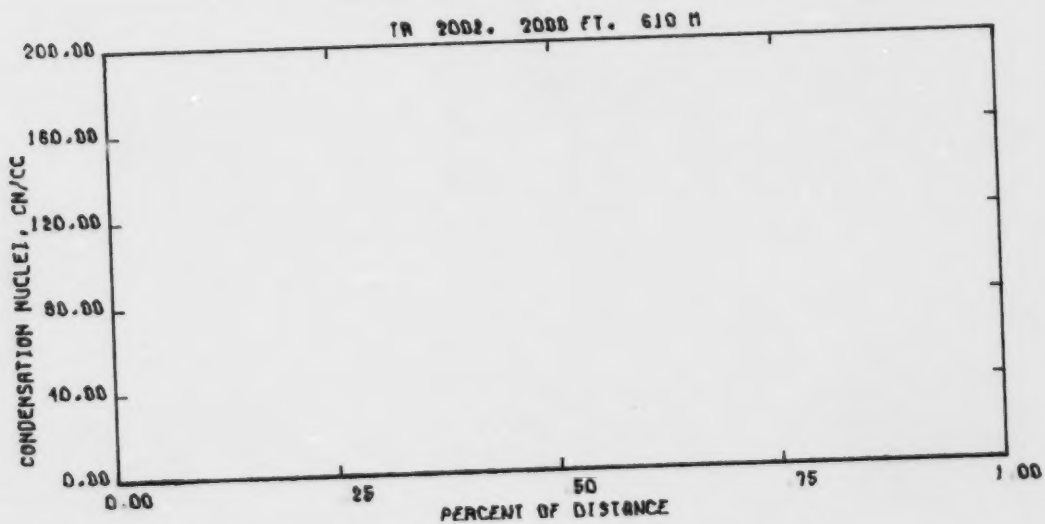
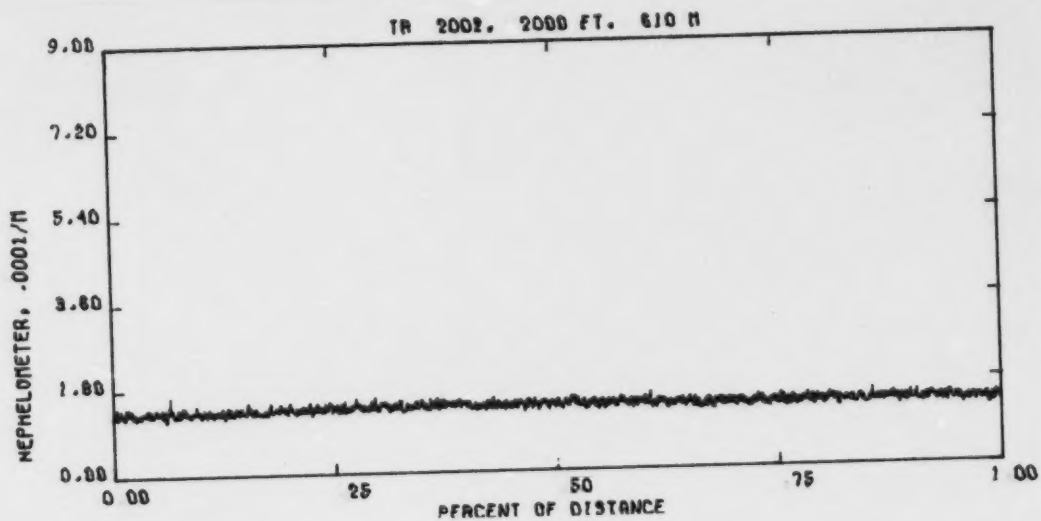
PAGE NUMBER

EPA-267 (Cin.)
(4-78)

BOTTOM OF
IMAGE AREA
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUSTRATIONS

TR. 2002, 2000 FT, 610 M. POINTS J TO D

7/18/74, 15:34:59 TO 15:52:54, DISTANCE= 77.4 KM



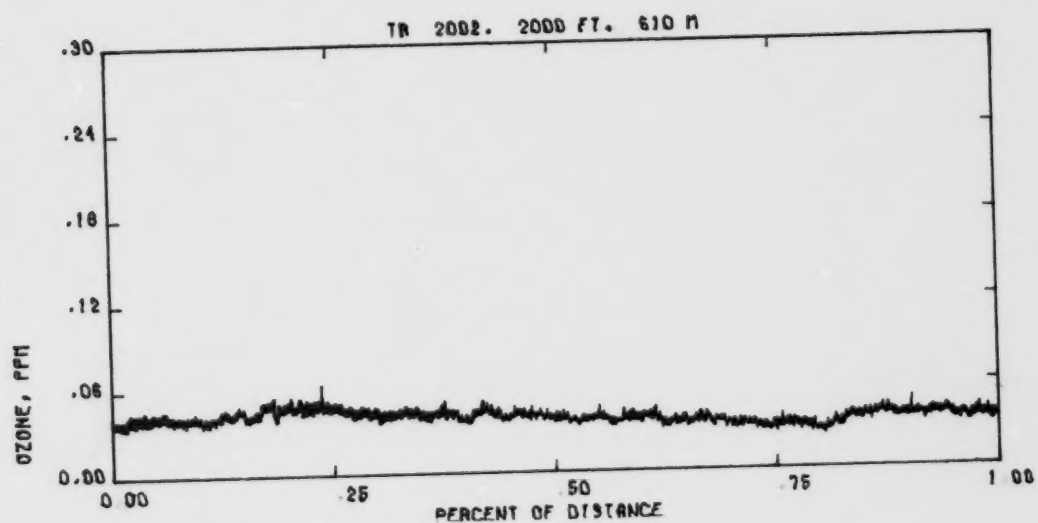
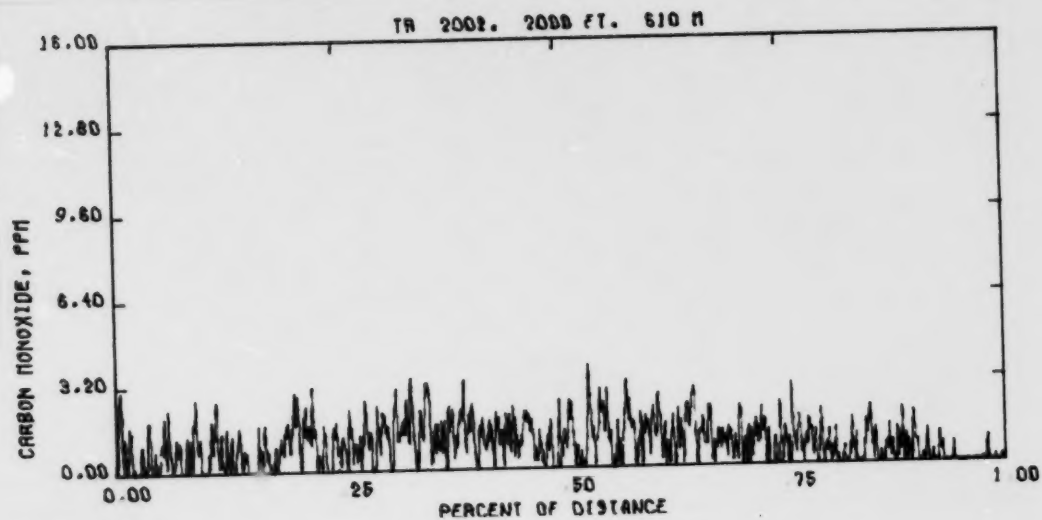
LAST LINE
OF TEXT

3/8"

34

PAGE NUMBER

OUTSIDE
DIMENSION
FOR TABLES
AND ILLUS-
TRATIONS



BEGIN
LAST LINE
OF TEXT

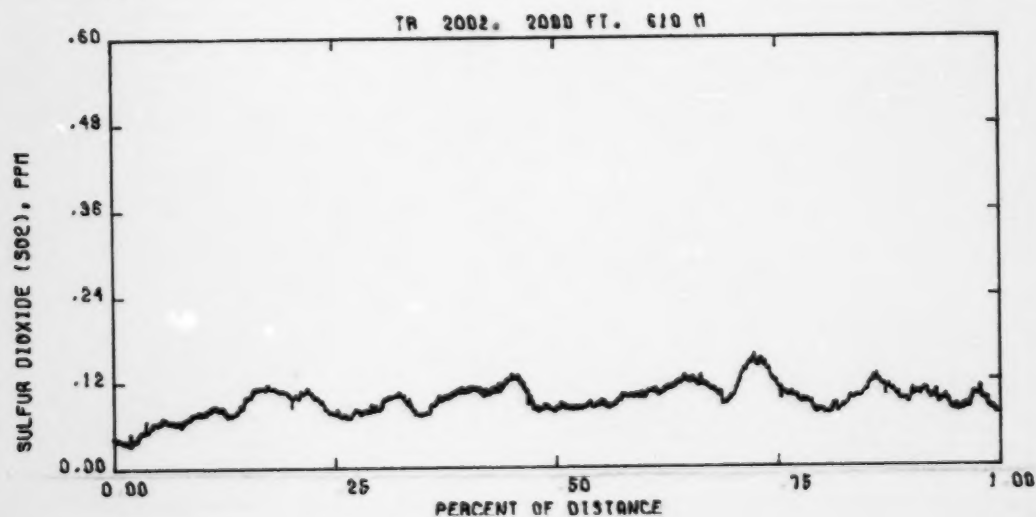
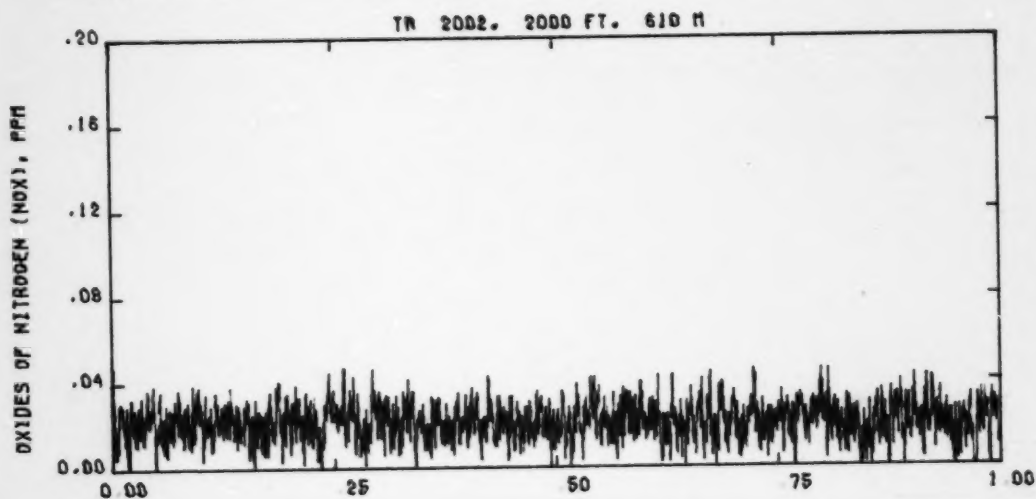
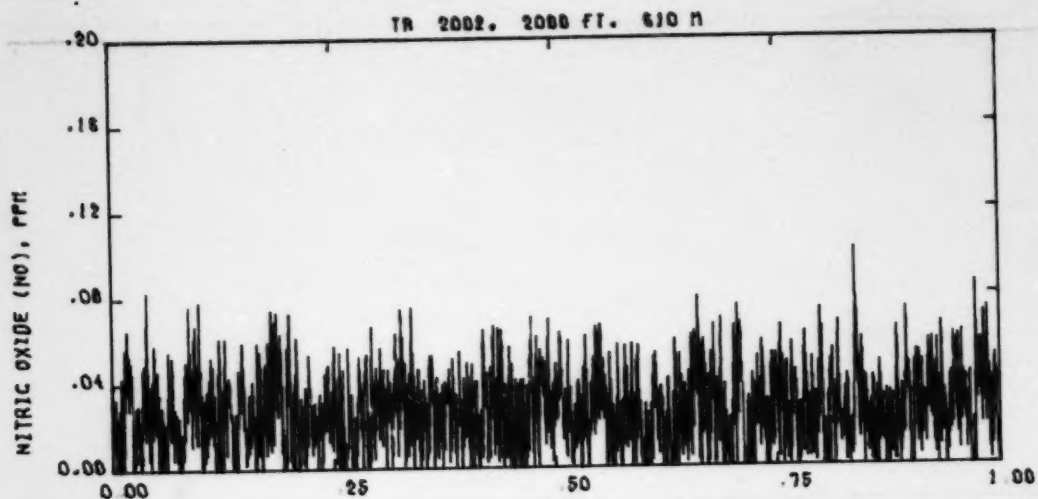
3.8"

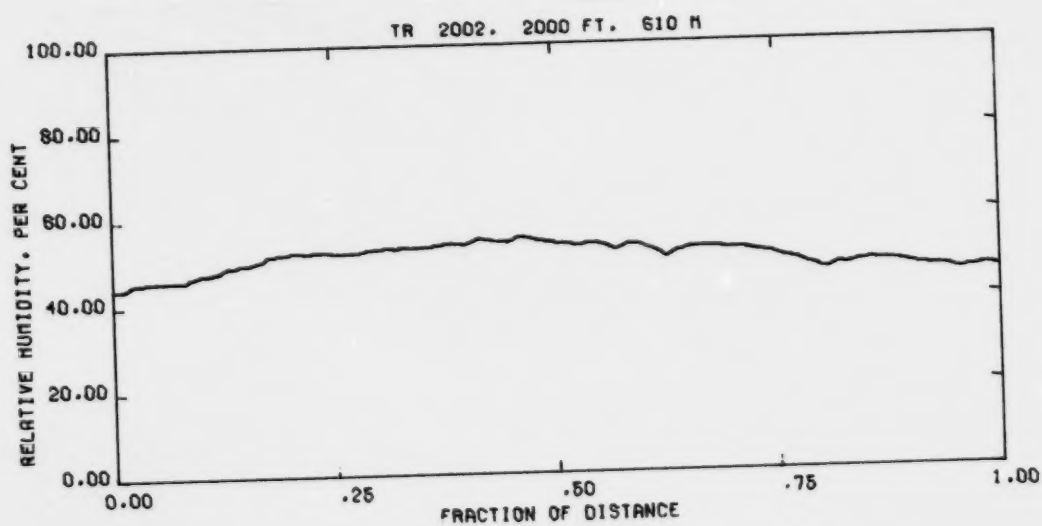
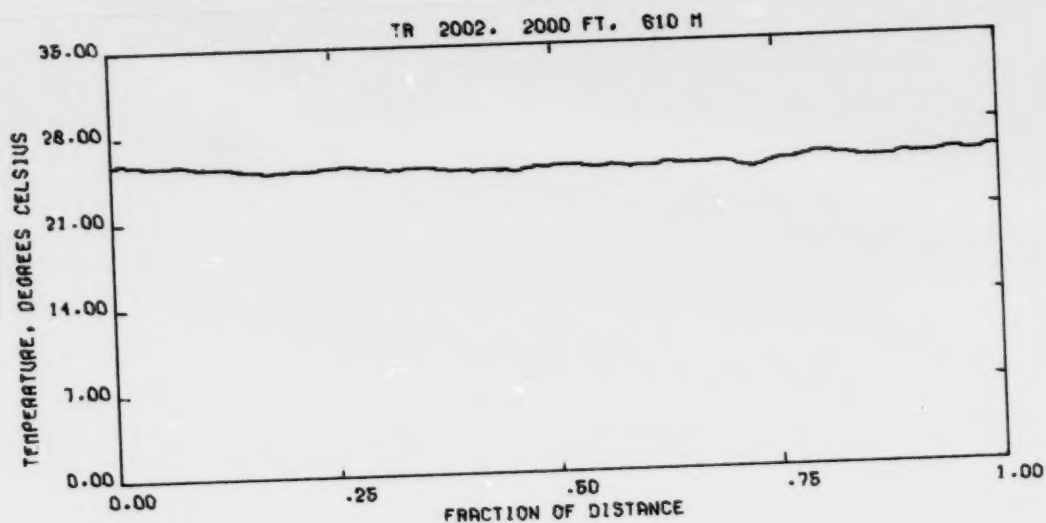
35

PAGE NUMBER

EPA-287 (Cm.)
(4-76)

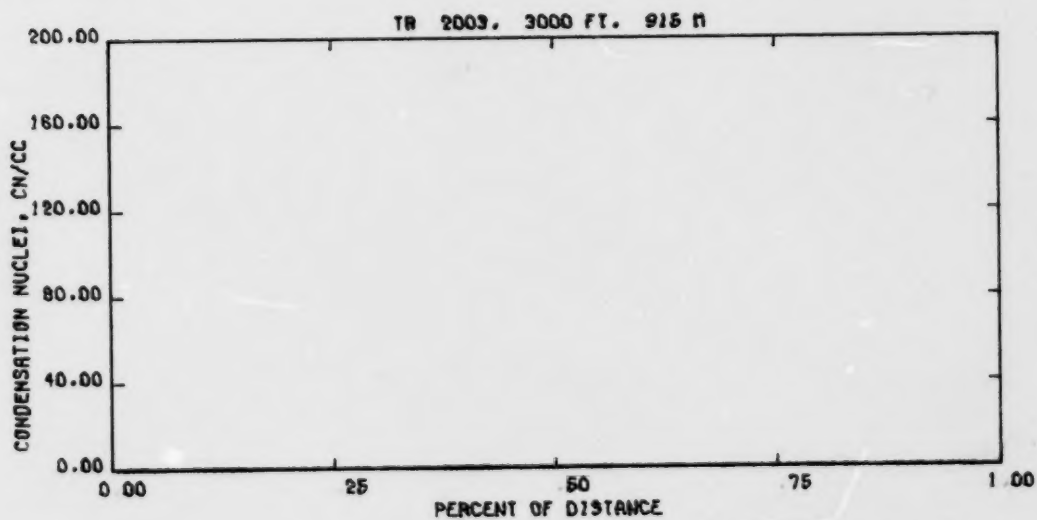
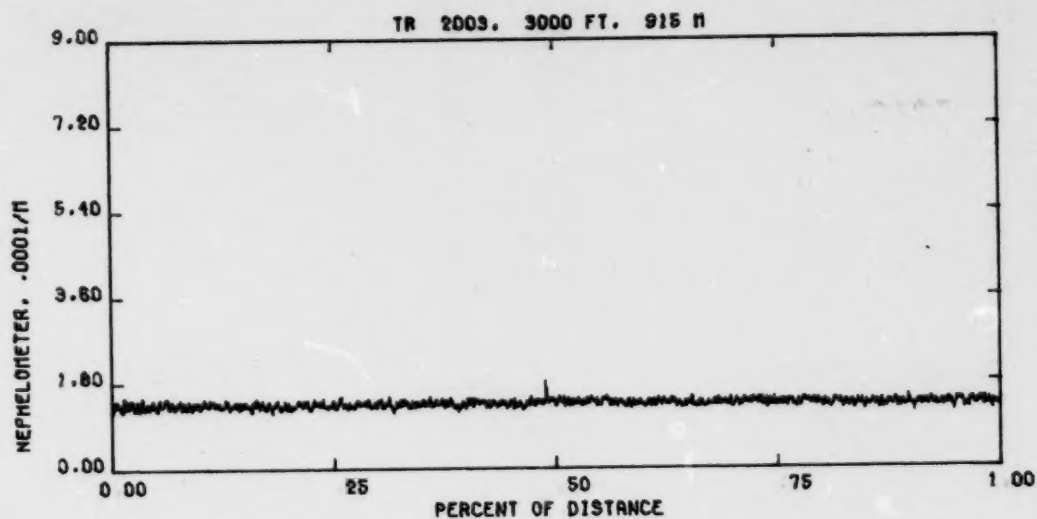
IMAGE AREA
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUS-
TRATIONS





TR. 2003, 3000 FT, 915 M, POINTS J TO D

7/18/74, 15.65.48 TO 16. 9.52, DISTANCE= 77.4 KM



OF TEXT

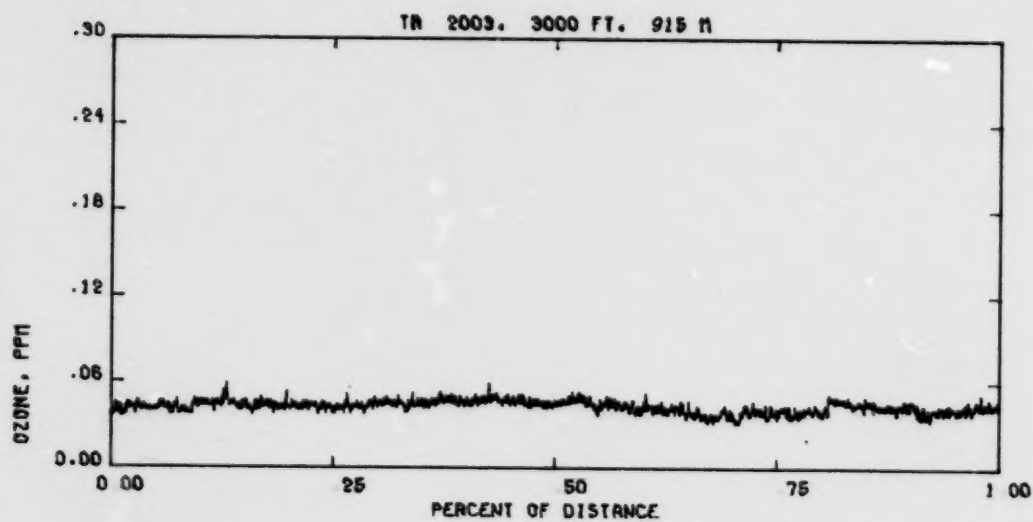
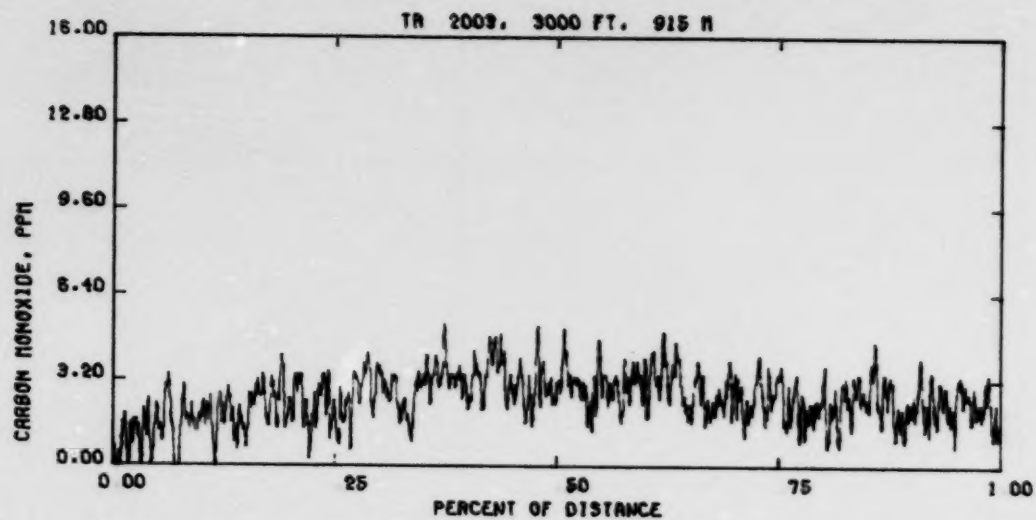
3/8"

38

PAGE NUMBER

EPA-287 (Cm.)
(4-75)

DIMENSION
FOR TABLES
AND ILLUSTRATIONS



BEGIN
LAST LINE
OF TEXT

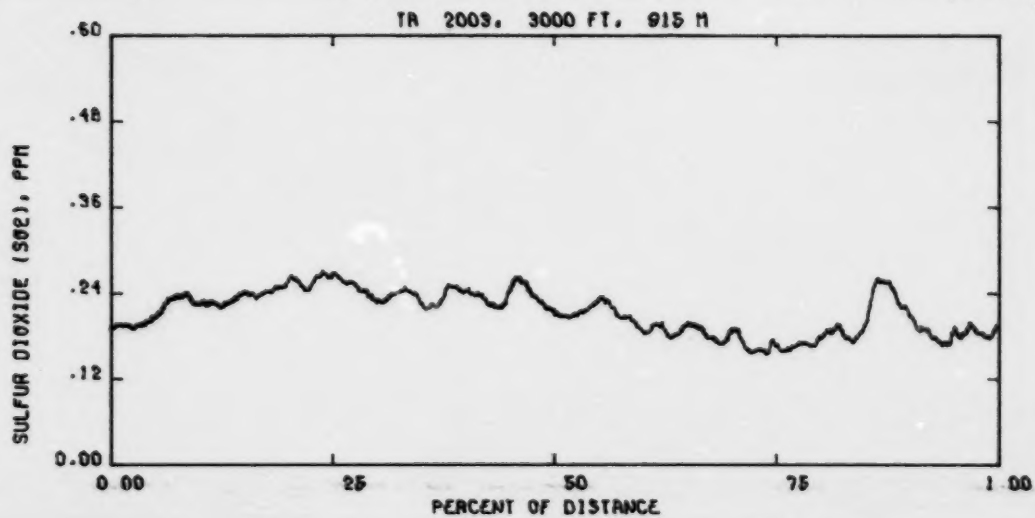
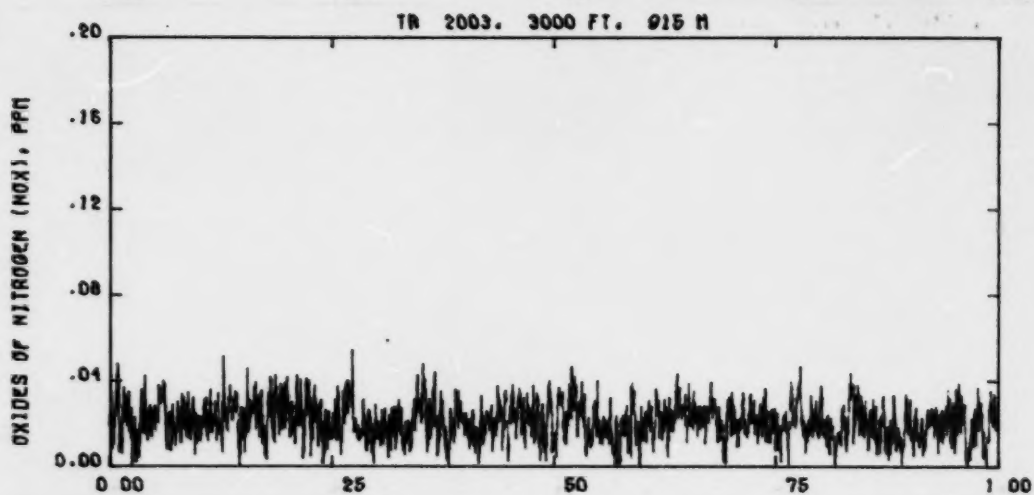
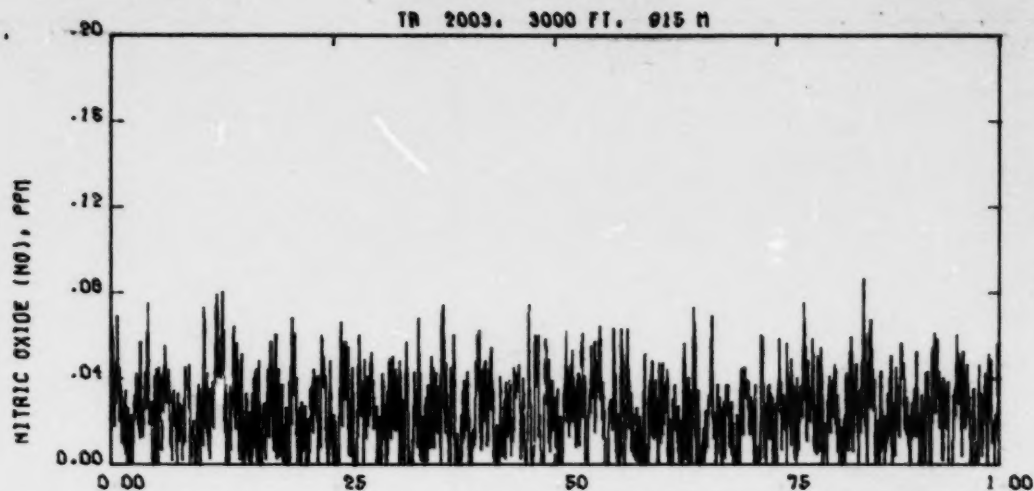
3/8"

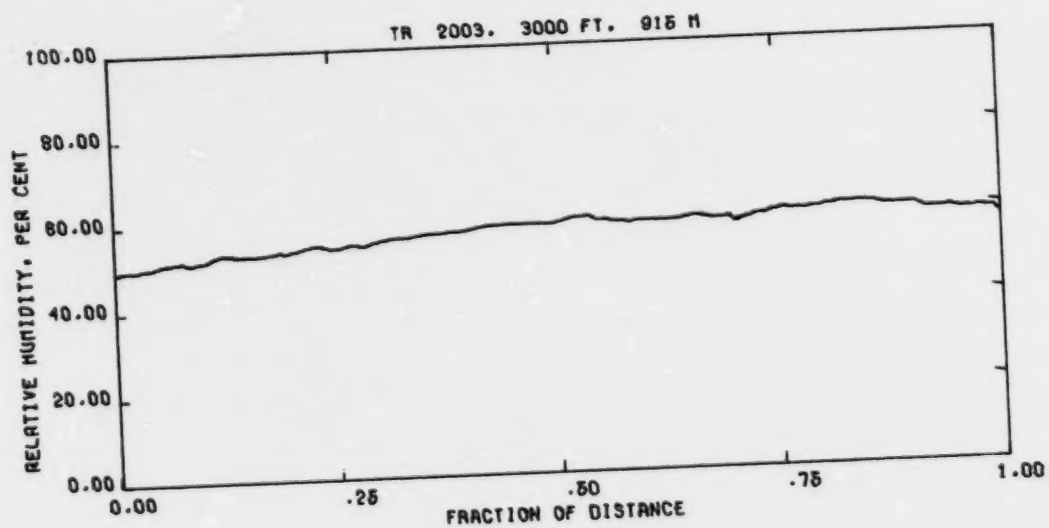
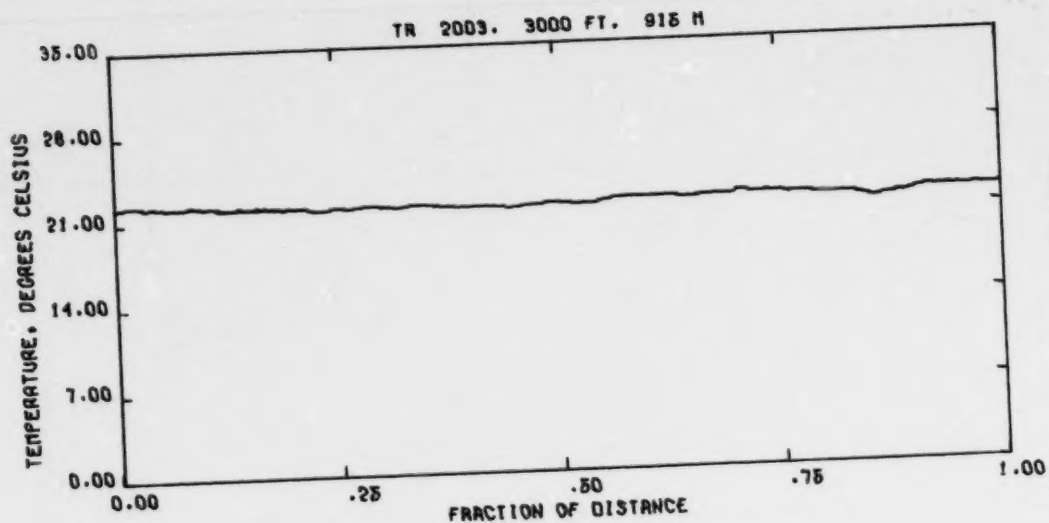
39

PAGE NUMBER

EPA-287 (Cin.)
(4-76)

IMAGE AREA
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUSTRATIONS





OF TEXT

3/8"

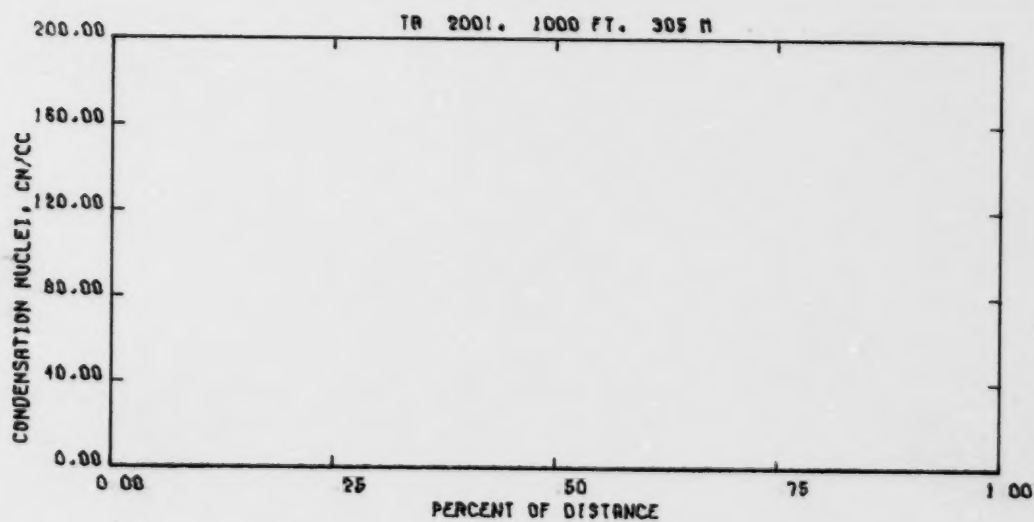
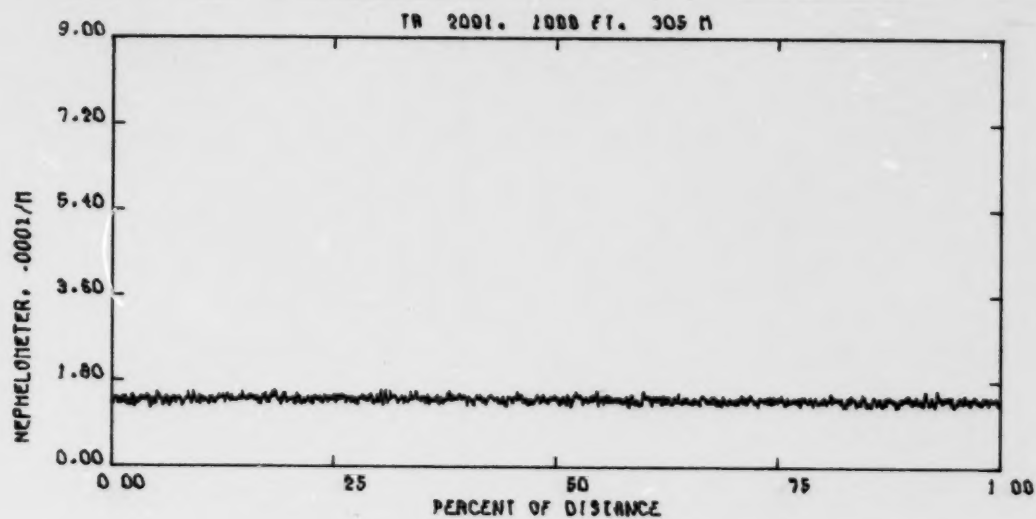
41

PAGE NUMBER

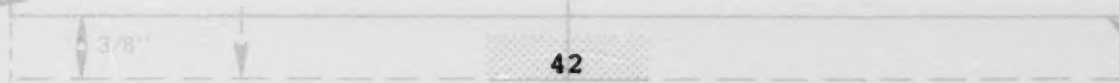
DIMENSION
FOR TABLES
AND ILLUSTRATIONS

TR. 2001. 1000 FT. 305 M. POINTS J TO D

7/18/74. 15:16:33 TO 15:31:2. DISTANCE= 77.4 KM



OF TEXT

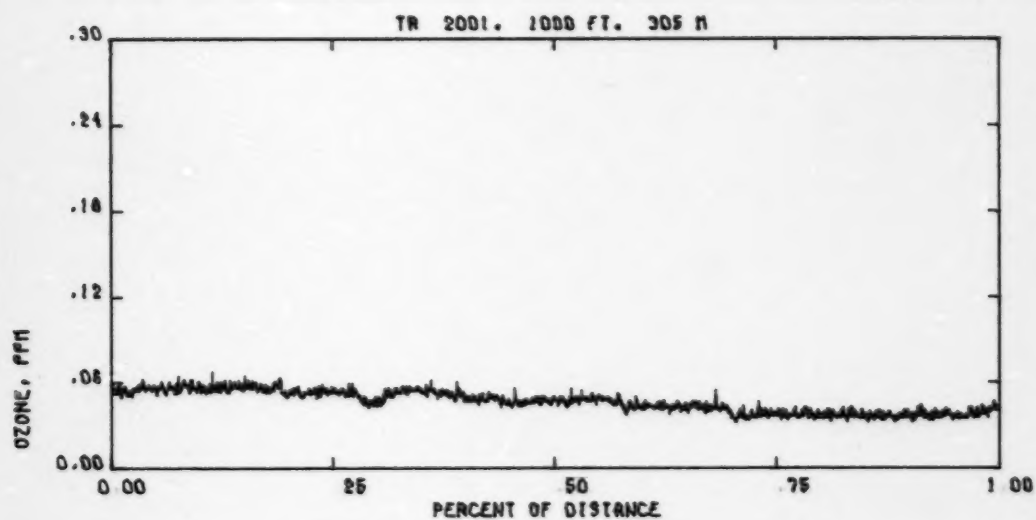
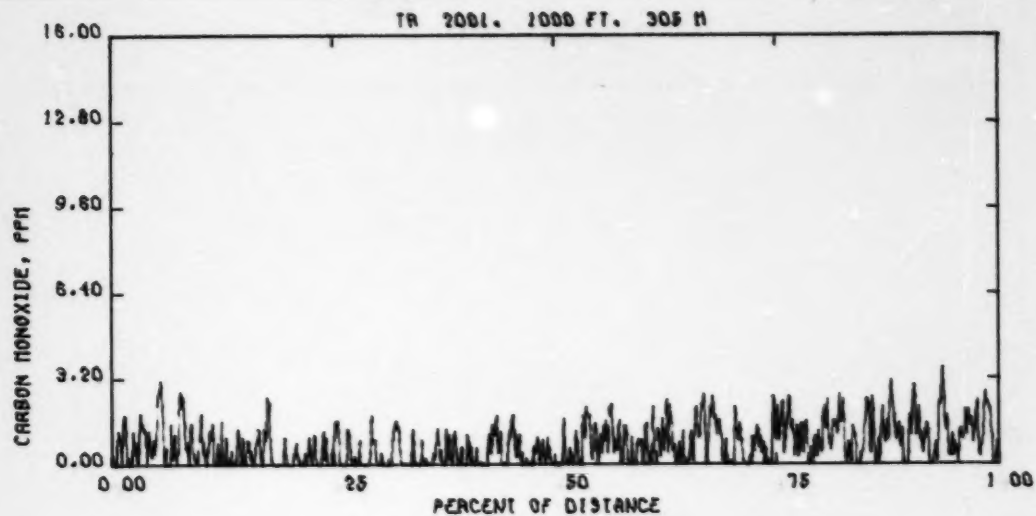


42

PAGE NUMBER

FOR TABLES
AND ILLUSTRATIONS

EPA-287 (Cir.)
(4-75)



BELOW
LAST LINE
OF TEXT

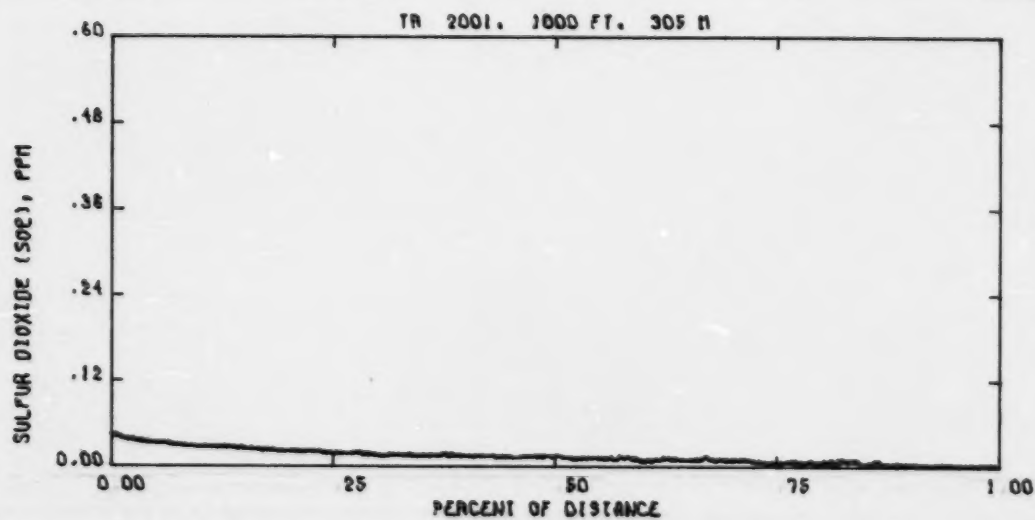
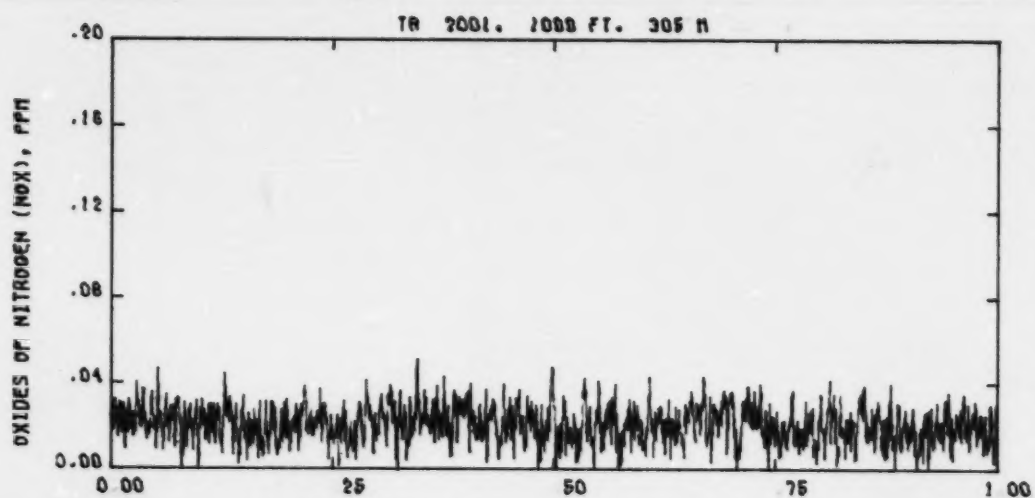
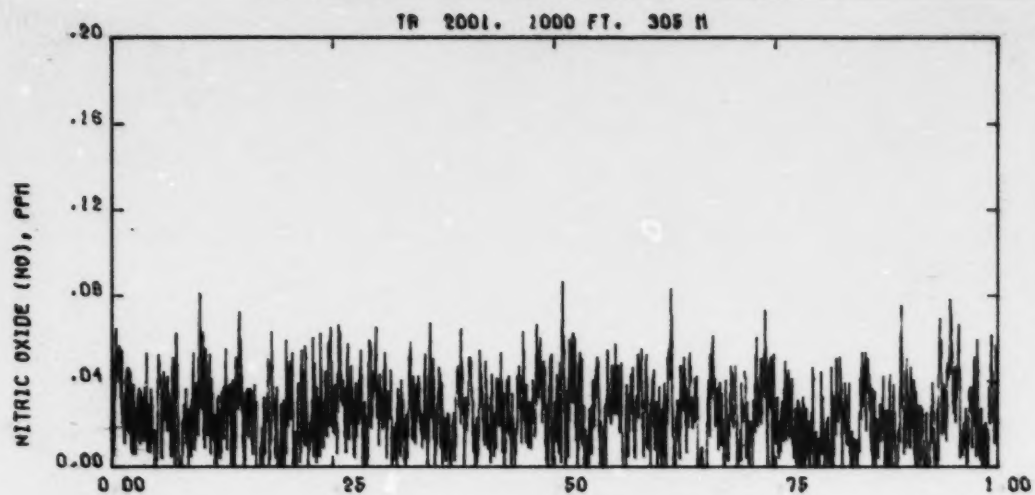
3/8"

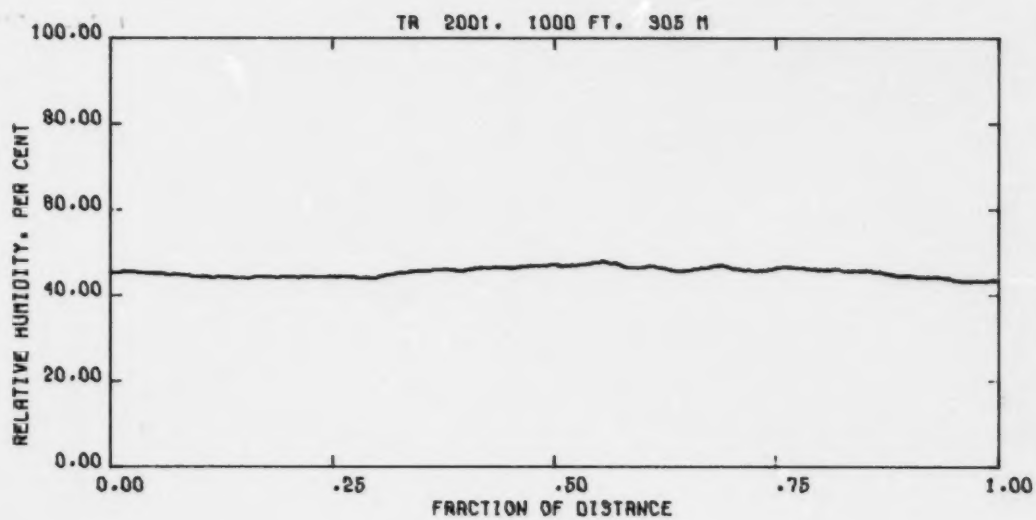
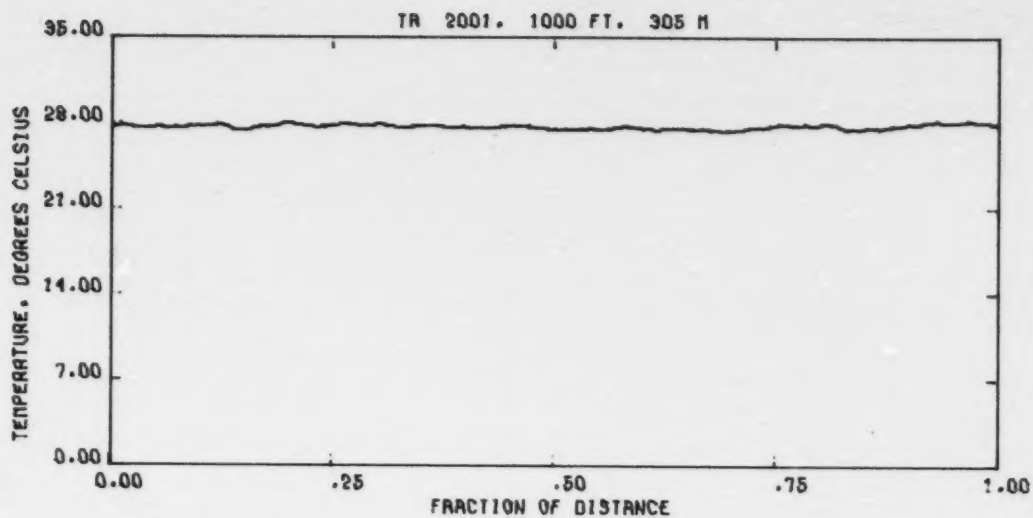
43

PAGE NUMBER

EPA-287 (Cin.)
(4-76)

OUTSIDE
DIMENSION
FOR TABLES
AND ILLUSTRATIONS





BEGIN
LAST LINE
OF TEXT

3/8"

45

PAGE NUMBER

EPA-287 (Cin.)
(4-76)

OUTSIDE
DIMENSION
FOR TABLES
AND ILLUS-
TRATIONS

BEGIN
FIRST
LINE OF
TEXT
HERE

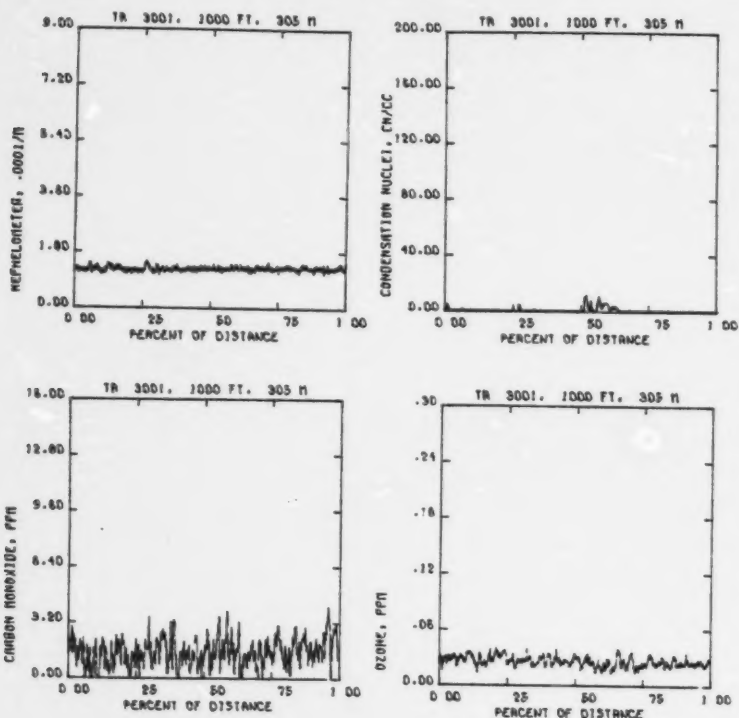
TYPING GUIDE SHEET

TOP OF
IMAGE
AREA

DROPPED
HEAD;
BEGIN
SECTION
HERE

TR. 3001. 1000 FT. 305 M. POINTS L TO A

7/19/74. 9.26.47 TO 9.35.48. DISTANCE= 36.2 KM



BEGIN
LAST LINE
OF TEXT

3/8"

46

PAGE NUMBER

EPA-287 (Cir.)
(4-76)

BOTTOM OF
IMAGE AREA,
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUSTRATIONS

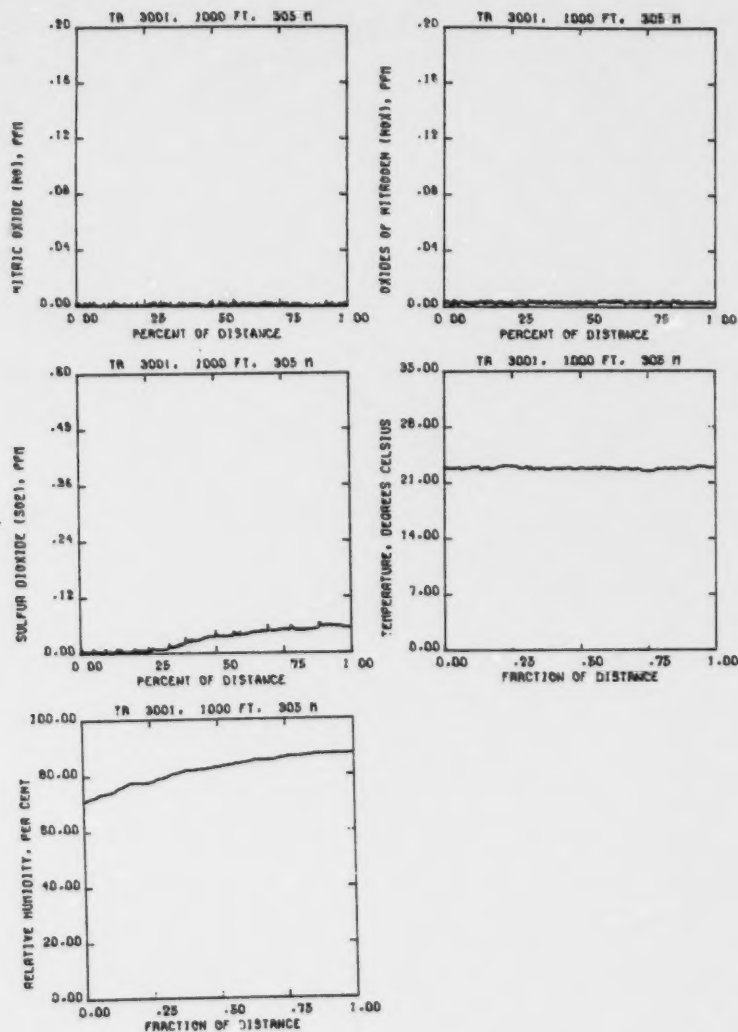
BEGIN
FIRST
LINE OF
TEXT
HERE

TYPING GUIDE SHEET

CENTER
OF PAGE

TOP OF
IMAGE
AREA

DROPP
HEAD;
BEGIN
SECTION
HERE



BEGIN
LAST LINE
OF TEXT

3/8"

BOTTOM OF
IMAGE AREA;
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUSTRATIONS

BEGIN
FIRST
LINE OF
TEXT
HERE

TYPING GUIDE SHEET

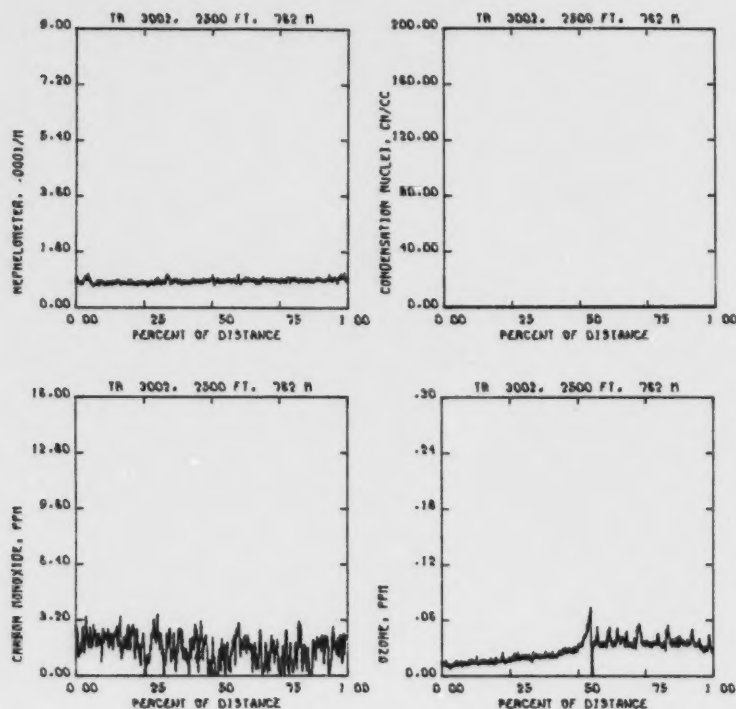
CENTER
OF PAGE

TOP OF
IMAGE
AREA

DROPPED
HEAD
BEGIN
SECTION
HERE

TR. 3002, 2500 FT. 762 M. POINTS L TO A

7/19/74, 9:46:33 TO 9:56:43, DISTANCE= 36.2 KM



BEGIN
LAST LINE
OF TEXT

3/8"

48

PAGE NUMBER

EPA-287 (Cin.)
(4-76)

BOTTOM OF
IMAGE AREA
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUSTRATIONS

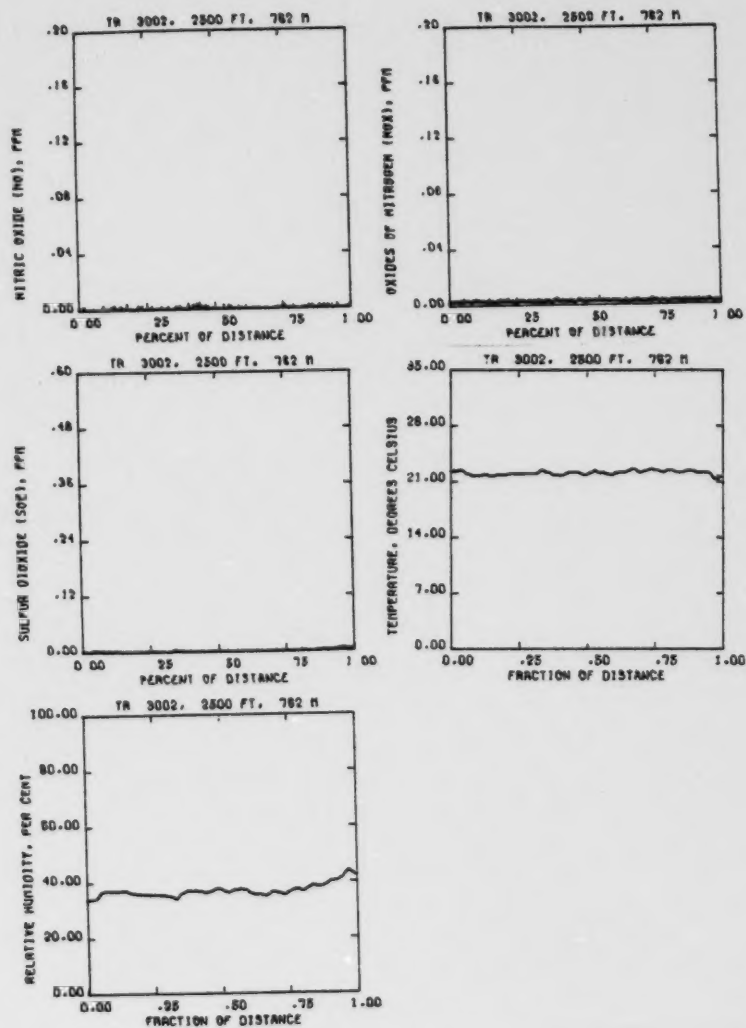
BEGIN
FIRST
LINE OF
TEXT
HERE

TYPING GUIDE SHEET

CENTER
OF PAGE

TOP OF
IMAGE
AREA

DROPPED
HEAD:
BEGIN
SECTIONS
HERE



BEGIN
LAST LINE
OF TEXT

3/8"

49

PAGE NUMBER

BOTTOM OF
IMAGE AREA,
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUS-
TRATIONS

BEGIN
FIRST
LINE OF
TEXT
HERE

TYPING GUIDE SHEET

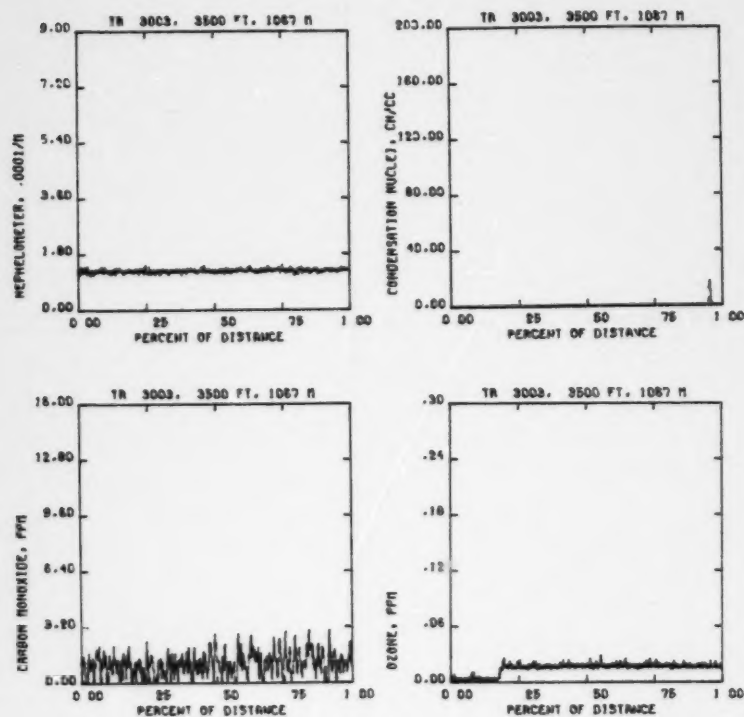
CENTER
OF PAGE

TOP OF
IMAGE
AREA

DROPPE
HEAD
BEGIN
SECTION
HERE

TR. 3003. 3500 FT. 1067 M. POINTS L TO R

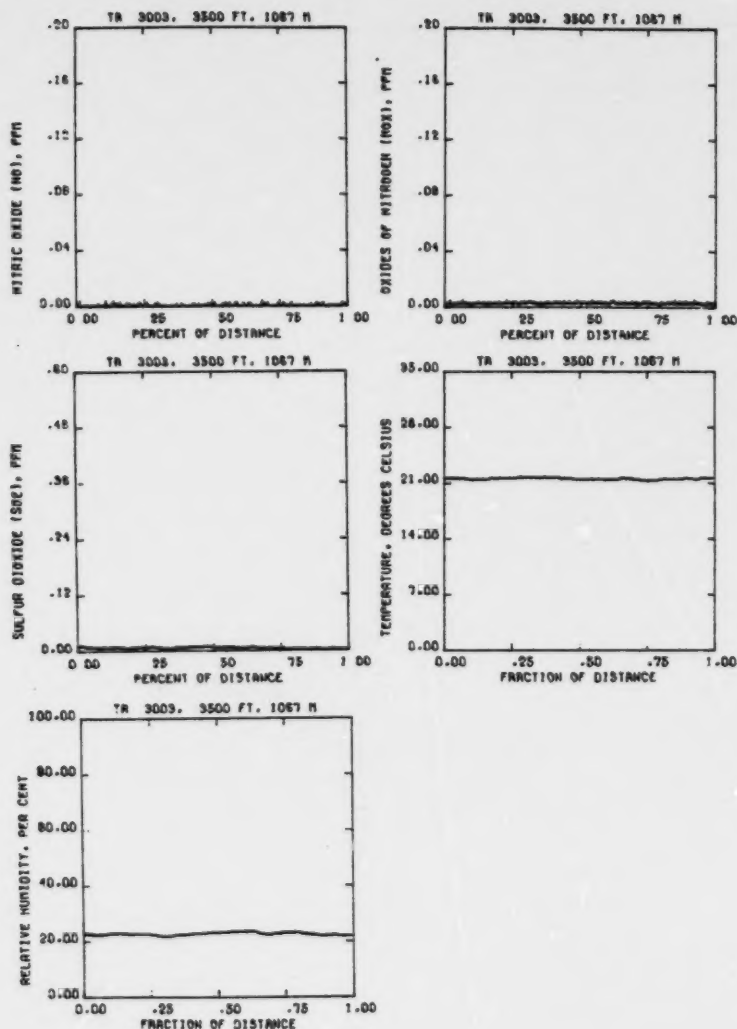
7/19/74. 10:11 TO 10:10:34. DISTANCE= 36.2 KM



BEGIN
LAST LINE
OF TEXT

BOTTOM OF
IMAGE AREA
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUSTRATIONS

3/8"



BEGIN
FIRST
LINE OF
TEXT
HERE

TYPING GUIDE SHEET

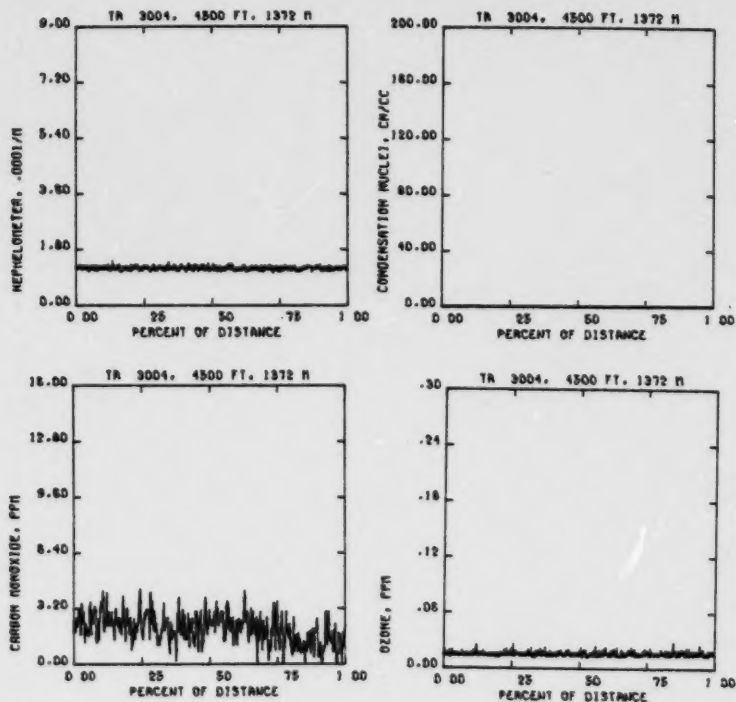
CENTER
OF PAGE

TOP OF
IMAGE
AREA

DROPPED
HEAD
BEGIN
SECTION
HERE

TR. 3004. 4500 FT. 1372 M. POINTS L TO R

7/19/74. 10:14:21 TO 10:24: 7. DISTANCE= 36.2 KM



BEGIN
LAST LINE
OF TEXT

3/8"

52

PAGE NUMBER

EPA-287 (Cin.)
(4-76)

BOTTOM OF
IMAGE AREA,
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUSTRATIONS

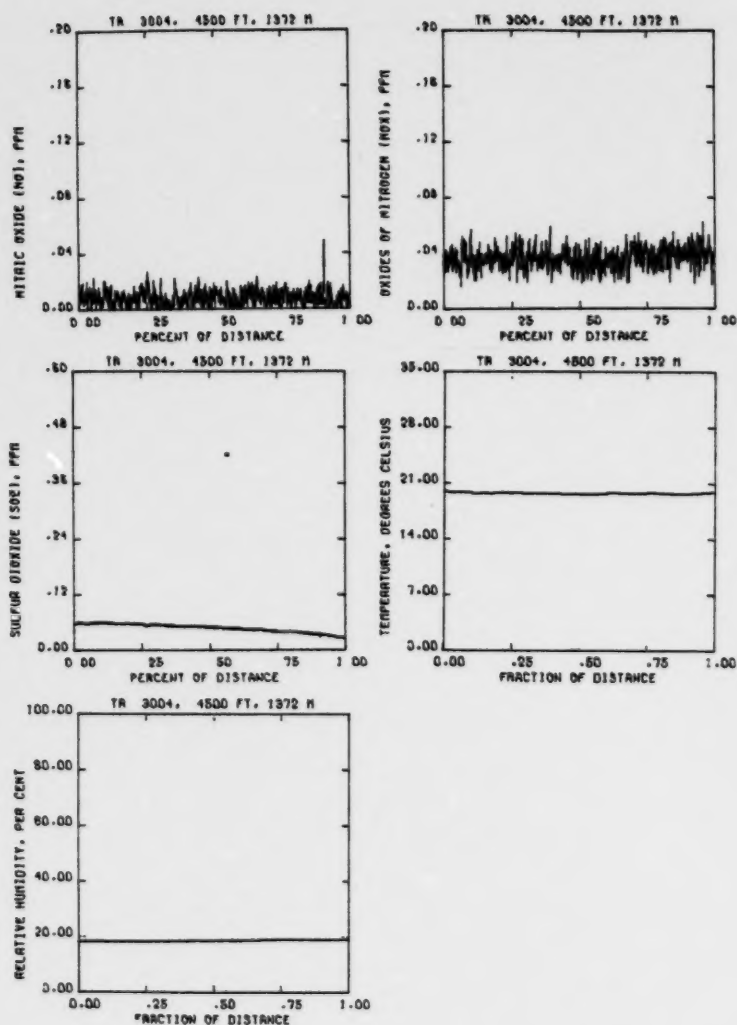
BEGIN
FIRST
LINE OF
TEXT
HERE

TYPING GUIDE SHEET

CENTER
OF PAGE

TOP OF
IMAGE
AREA

DROPPED
HEAD
BEGIN
SECTION!
HERE 1



BEGIN
LAST LINE
OF TEXT

BOTTOM OF
IMAGE AREA
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUSTRATIONS

BEGIN
FIRST
LINE OF
TEXT
HERE

TYPING GUIDE SHEET

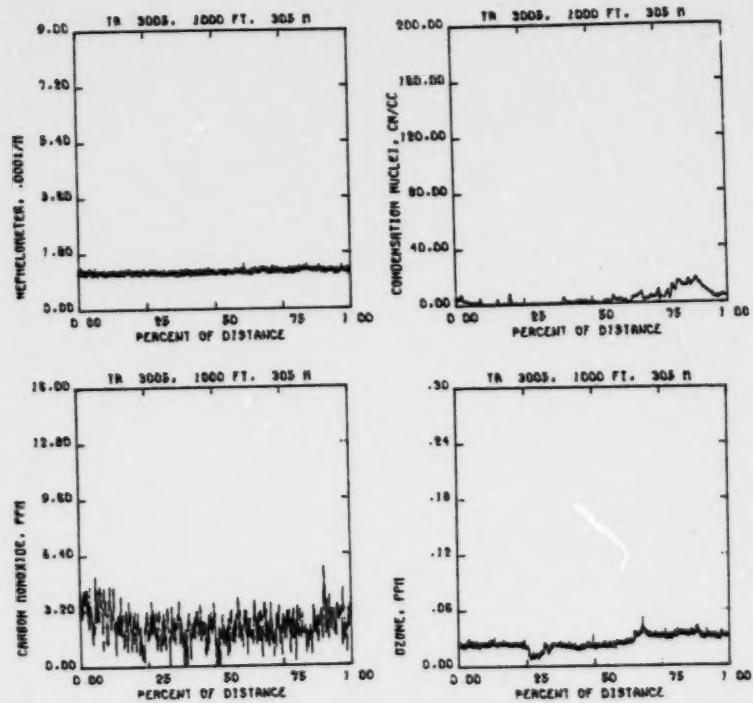
CENTER

TOP OF
IMAGE
AREA

DROPPED
HEAD
BEGIN
SECTION
HERE

TR. 3005, 1000 FT. 305 M. POINTS L TO R

7/19/74, 10:30:47 TO 10:46:30. DISTANCE= 36.2 MM



BEGIN
LAST LINE
OF TEXT

3/8"

54

PAGE NUMBER

EPA-287 (Cin.)
(4-76)

BOTTOM OF
IMAGE AREA,
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUS-
TRATIONS

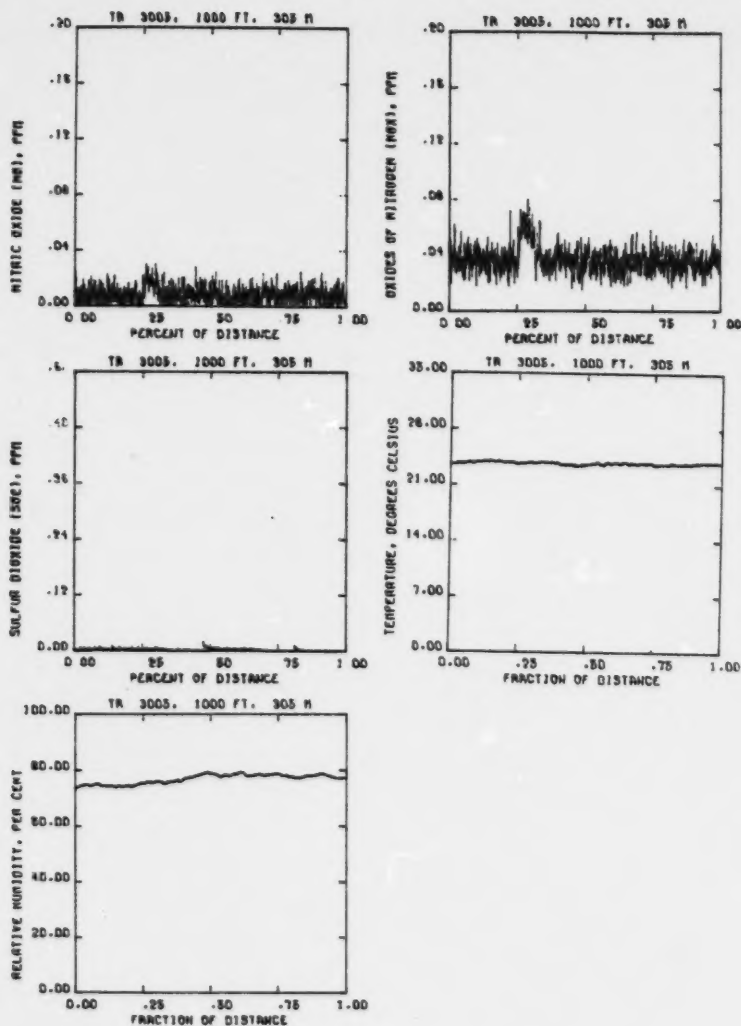
BEGIN
FIRST
LINE OF
TEXT
HERE

TYPING GUIDE SHEET

CENTER
OF PAGE

TOP OF
IMAGE
AREA

DROPPY
HEAD:
BEGIN
SECTIC
HERE



BEGIN
LAST LINE
OF TEXT

3/8"

BOTTOM OF
IMAGE AREA
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUS-
TRATIONS

BEGIN
FIRST
LINE OF
TEXT
HERE

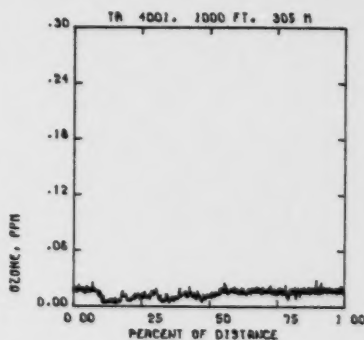
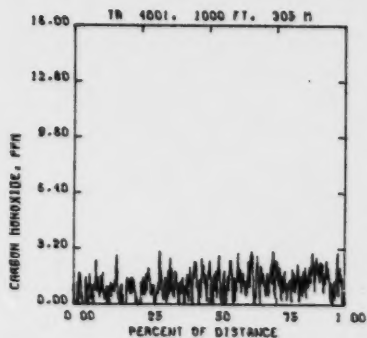
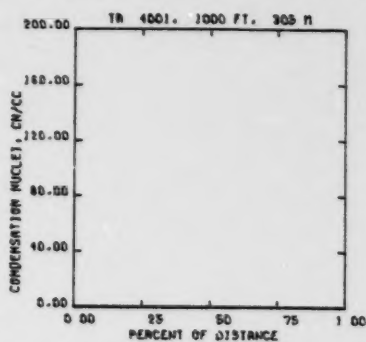
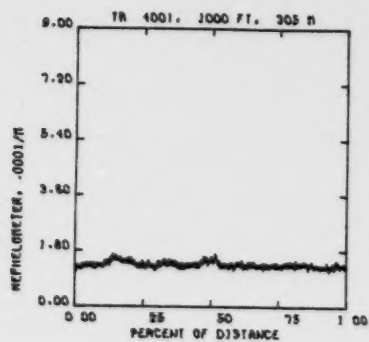
TYPING GUIDE SHEET

TOP OF
IMAGE
AREA

DROPPED
HEAD:
BEGIN
SECTION
HERE

TR. 4001, 1000 FT. 305 M. POINTS L TO A

7/20/74, 8:27:47 TO 8:37:25, DISTANCE= 36.2 KM



BEGIN
LAST LINE
OF TEXT

BOTTOM OF
IMAGE AREA
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUS-
TRATIONS

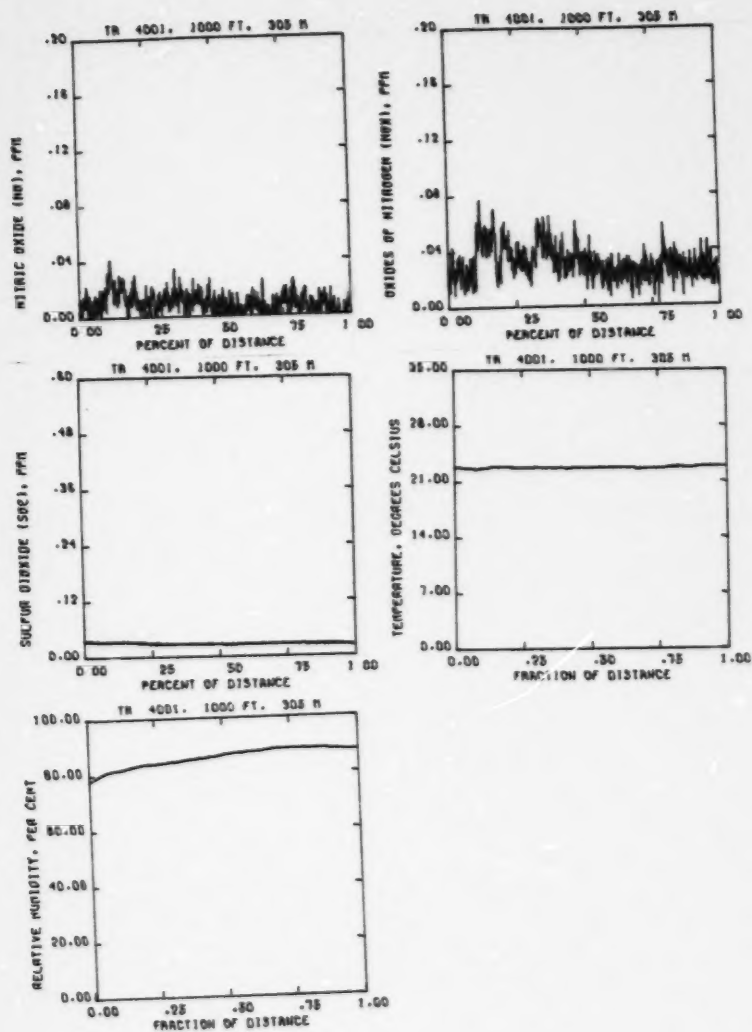
BEGIN
FIRST
LINE OF
TEXT
HERE

TYPING GUIDE SHEET

CENTER
OF PAGE

TOP OF
IMAGE
AREA

DROPPED
HEAD
BEGIN
SECTION
HERE



BEGIN
LAST LINE
OF TEXT

3/8"

57

PAGE NUMBER

BOTTOM OF
IMAGE AREA;
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUS-
TRATIONS

BEGIN
FIRST
LINE OF
TEXT
HERE

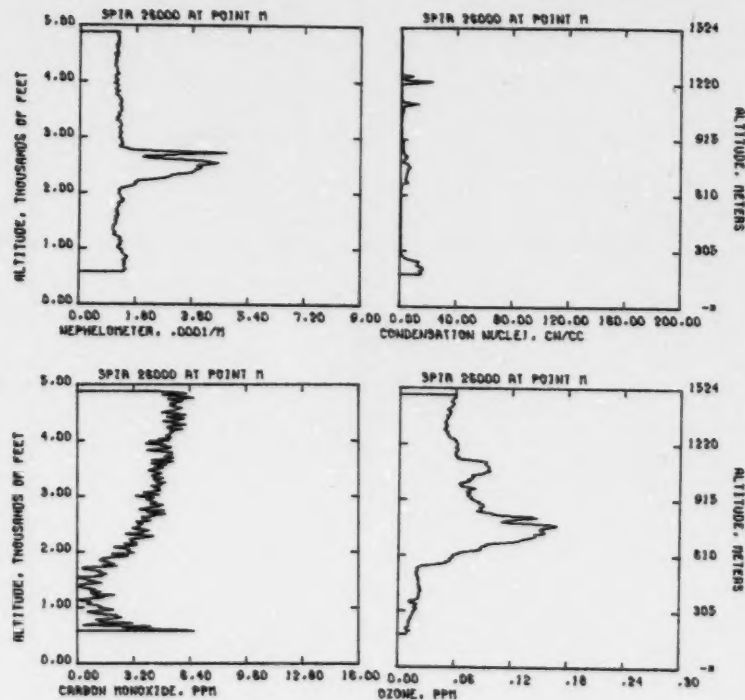
TYPING GUIDE SHEET

CENTER
OF PAGE

TOP OF
IMAGE
AREA

DROPPED
HEAD
BEGIN
SECTION
HERE

SPIRAL 26000 AT POINT N 580 TO 4800 FEET
177 TO 1468 METERS
7/20/74. 8:51:12 TO 9:00:00. DISTANCE= 4300 FEET
1311 METERS



BEGIN
LAST LINE
OF TEXT

BOTTOM OF
IMAGE AREA,
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUS-
TRATIONS

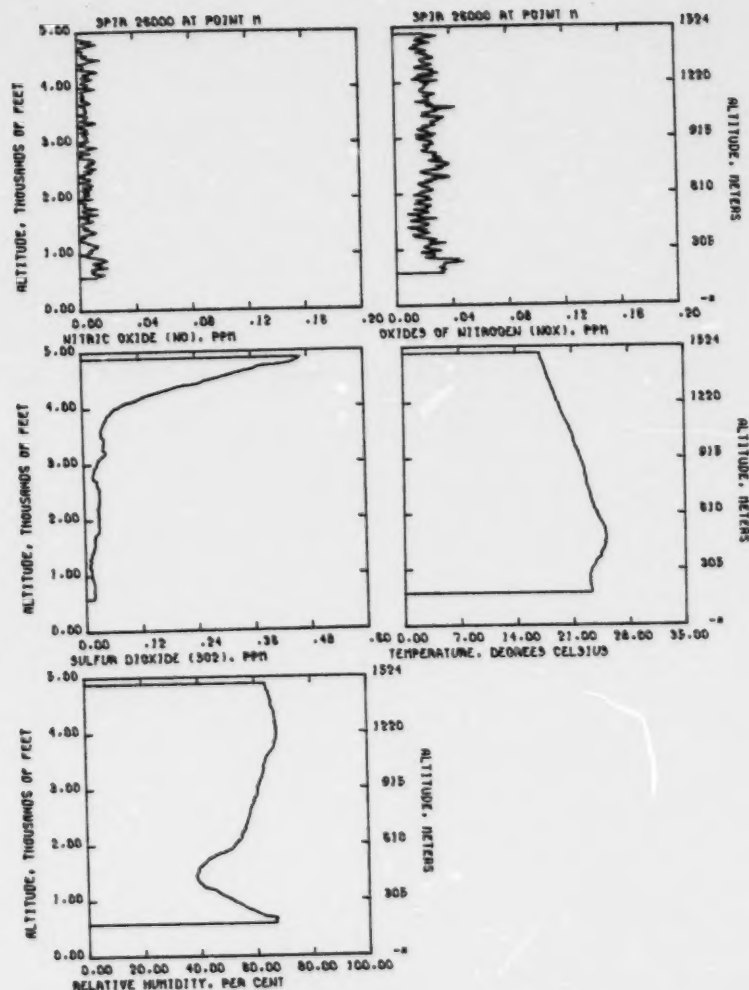
BEGIN
FIRST
LINE OF
TEXT
HERE

TYPING GUIDE SHEET

CENTER
OF PAGE

TOP OF
IMAGE
AREA

DROPPE
HEAD:
BEGIN
SECTION
HERE



BEGIN
LAST LINE
OF TEXT

BOTTOM OF
IMAGE AREA:
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUS-
TRATIONS

BEGIN
FIRST
LINE OF
TEXT
HERE 1

TYPING GUIDE SHEET

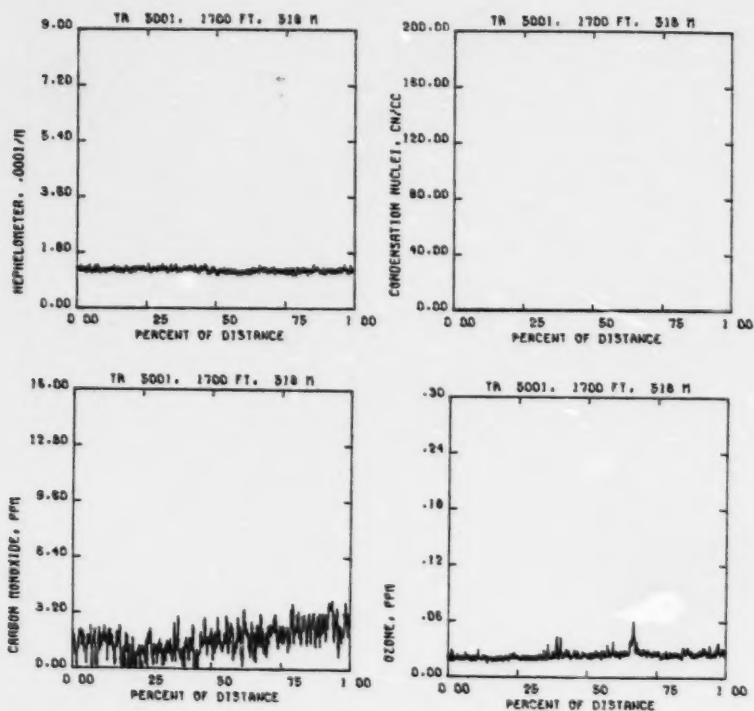
CENTER

TOP OF
IMAGE
AREA

DROPPED
HEAD,
BEGIN
SECTION
HERE

TR. 5001, 1700 FT, 518 M, POINTS M TO Q

7/20/74, 9:4.13 TO 9:14.43, DISTANCE= 37.1 KM



BEGIN
LAST LINE
OF TEXT

3/8"

60

PAGE NUMBER

EPA-287 (Cir.)
(4-78)

BOTTOM OF
IMAGE AREA
DIMENSION
FOR TABLES
AND ILLUSTRATIONS

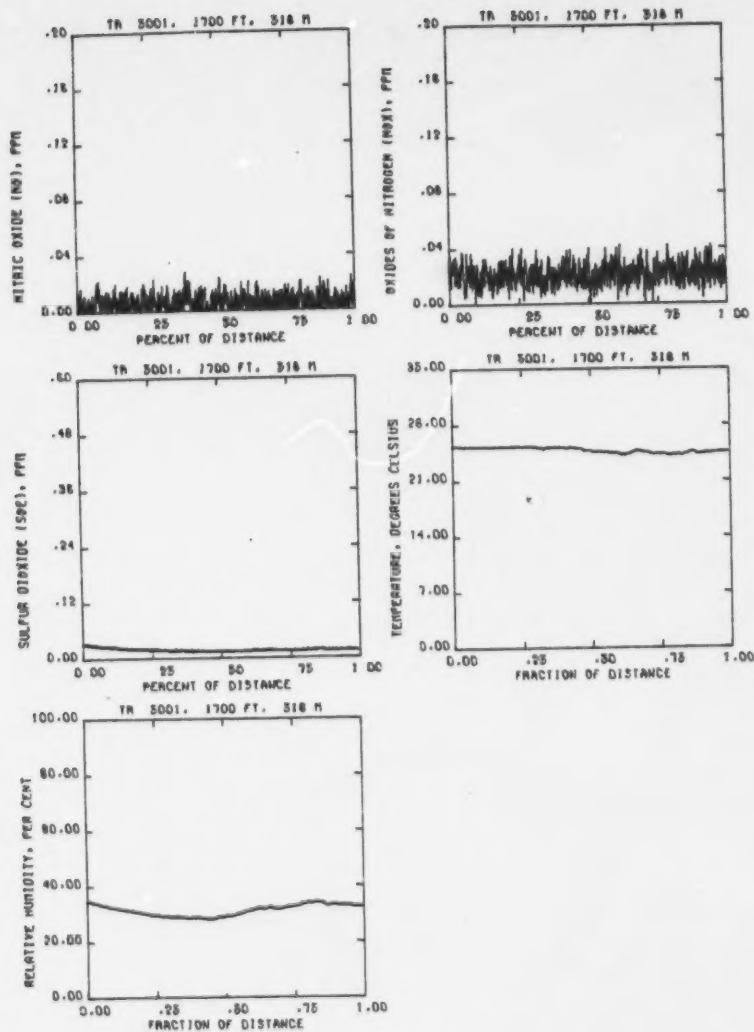
BEGIN
FIRST
LINE OF
TEXT
HERE

TYPING GUIDE SHEET

CENTER
OF PAGE

TOP OF
IMAGE
AREA

DROPPED
HEAD
BEGIN
SECTION
HERE



BEGIN
LAST LINE
OF TEXT

BOTTOM OF
IMAGE AREA
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUS-
TRATIONS

BEGIN
FIRST
LINE C
TEXT
HERE

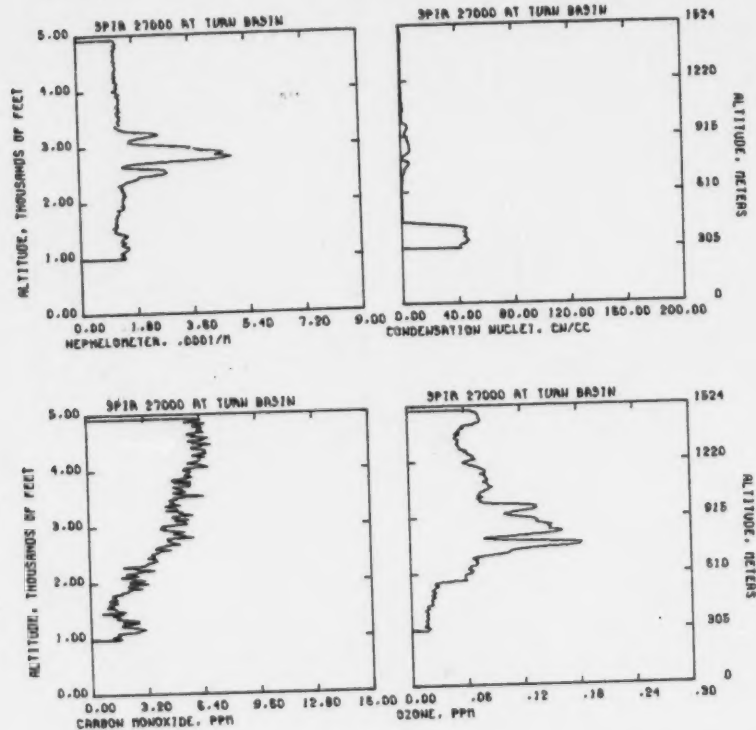
TYPING GUIDE SHEET

TOP OF
PAGE
AREA

DROPPED
HEAD
BEGIN
SECTION
HERE

SPIRAL 27000 AT TURN BASIN 980 TO 4920 FEET
299 TO 1500 METERS

7/20/74, 9:25, 8 TO 9:32:59, DISTANCE= 3940 FEET
1201 METERS



BEGIN
LAST LINE
OF TEXT

3/8"

62

PAGE NUMBER

EPA-287 (Cin.)
(4-76)

NOTION OF
WAGE AREA
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUS-
TRATIONS

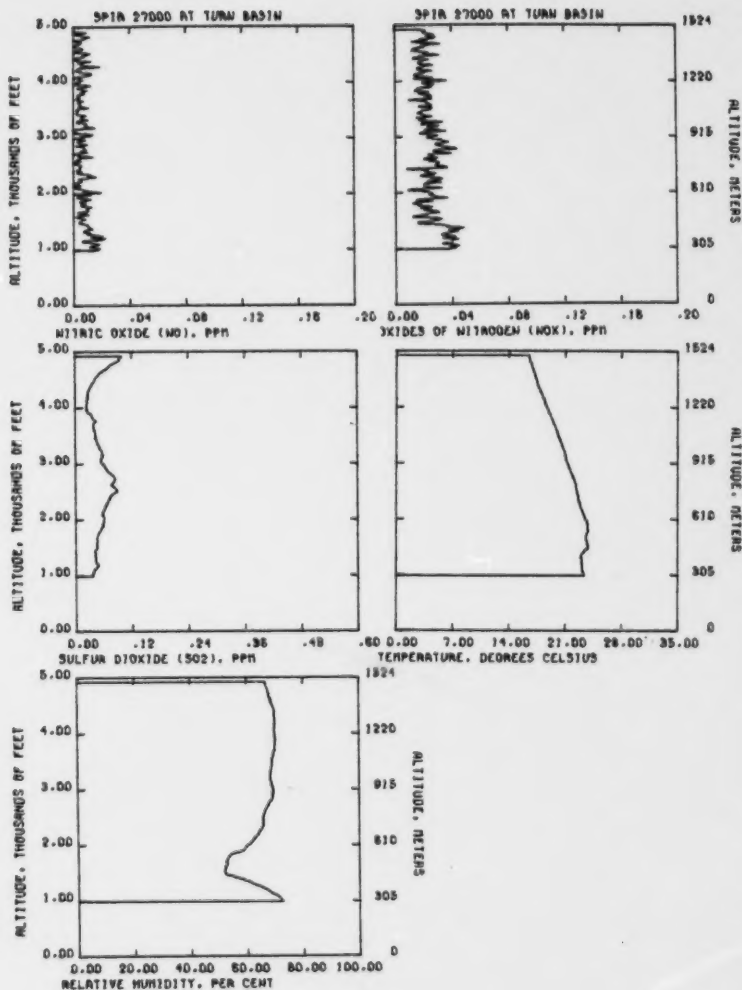
BEGIN
FIRST
LINE OF
TEXT
HERE

TYPING GUIDE SHEET

CENTER
OF PAGE

TOP OF
IMAGE
AREA

DROPPED
HEAD
BEGIN
SECTION
HERE



BEGIN
LAST LINE
OF TEXT

BOTTOM OF
IMAGE AREA
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUSTRATIONS

BEGIN
FIRST
LINE OF
TEXT
HERE

TYPING GUIDE SHEET

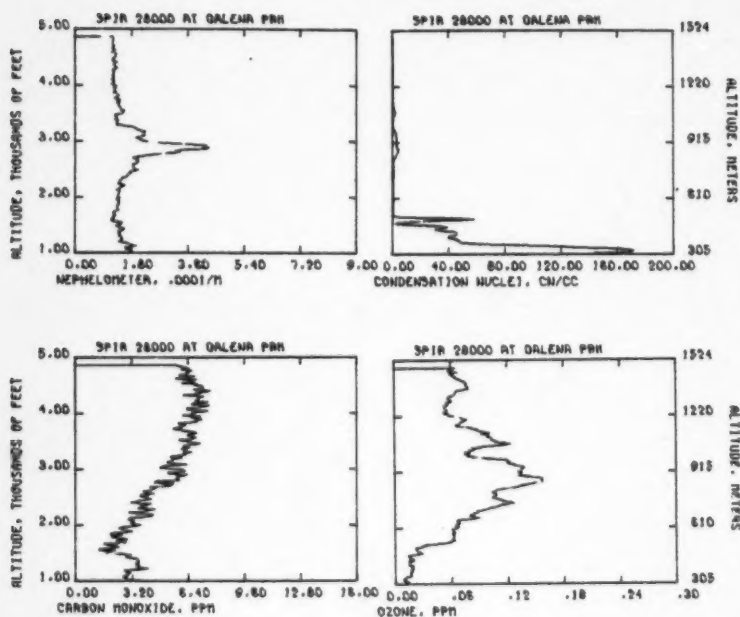
CENTER

TOP OF
PAGE
AREA

DROPPET
HEAD:
BEGIN
SECTION
HERE

SPIRAL 28000 AT GALENA PARK 1000 TO 4800 FEET
305 TO 1482 METERS

7/20/74, 9:46:11 TO 9:54:46, DISTANCE= 3860 FEET
1177 METERS



BEGIN
LAST LINE
OF TEXT

3/8"

64

PAGE NUMBER

EPA-267 (Cin.)
(4-76)

BOTTOM OF
IMAGE AREA
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUS-
TRATIONS

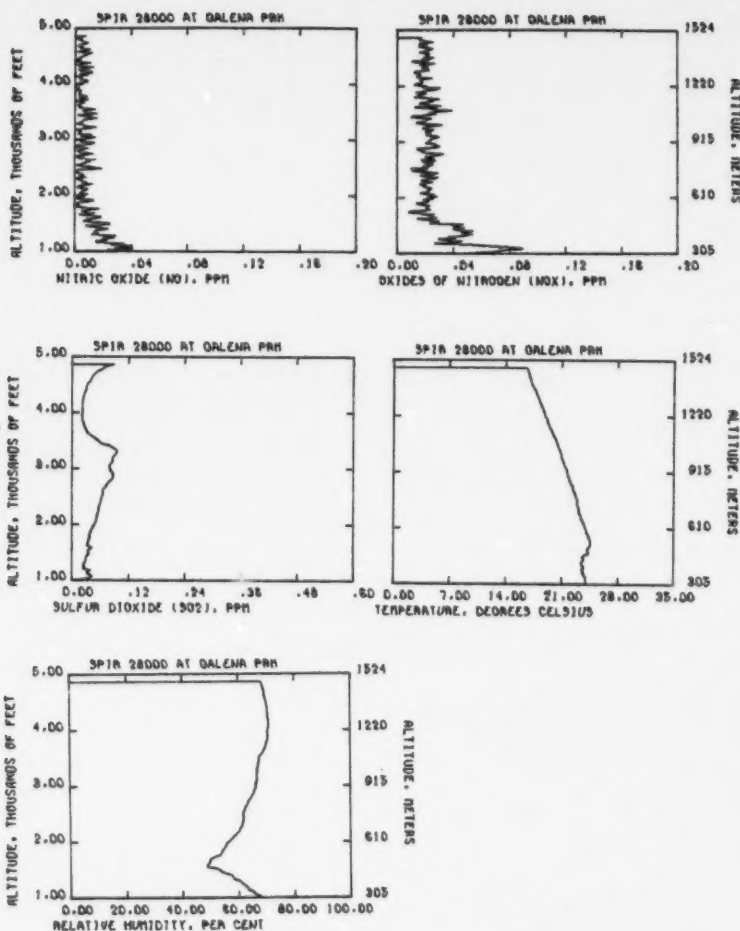
BEGIN
FIRST
LINE OF
TEXT
HERE

TYPING GUIDE SHEET

CENTER
OF PAGE

TOP OF
IMAGE
AREA

DROPPED
HEAD
BEGIN
SECTION
HERE



BEGIN
LAST LINE
OF TEXT

3/8"

65

PAGE NUMBER

EPA-287 (Cin.)
(4-76)

BOTTOM OF
IMAGE AREA
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUS-
TRATIONS

BEGIN
FIRST
LINE OF
TEXT
HERE

TYPING GUIDE SHEET

CENTER

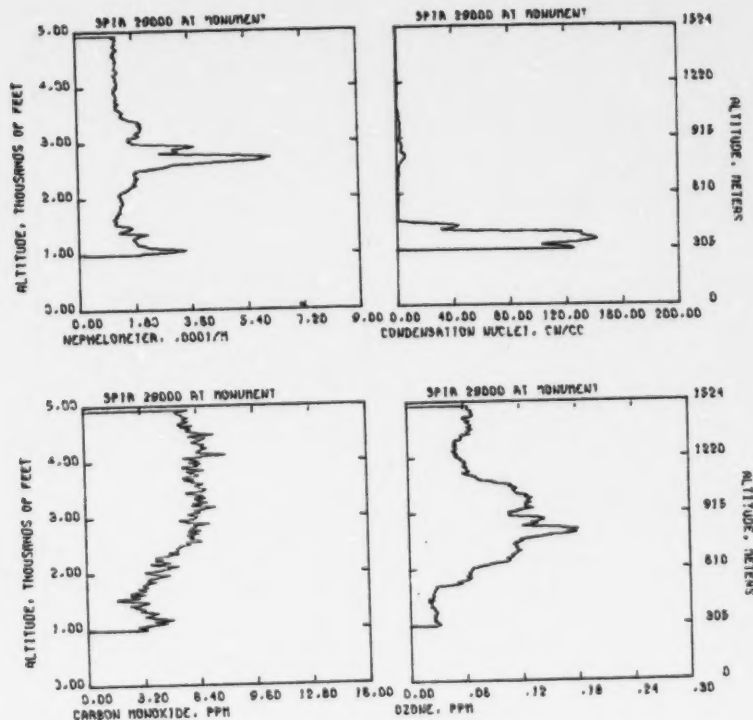
TOP OF
PAGE
AREA

DRG/PPF
HEAD
BEGIN
SECTION
HERE

SPIRAL 29000 AT MONUMENT

980 TO 4920 FEET
299 TO 1500 METERS

7/20/74, 10.6.11 TO 10.14.14, DISTANCE= 3940 FEET
1201 METERS



BEGIN
LAST LINE
OF TEXT

3/8"

66

PAGE NUMBER

EPA-287 (Cin.)
(4-76)

BOTTOM OF
IMAGE AREA,
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUS-
TRATIONS

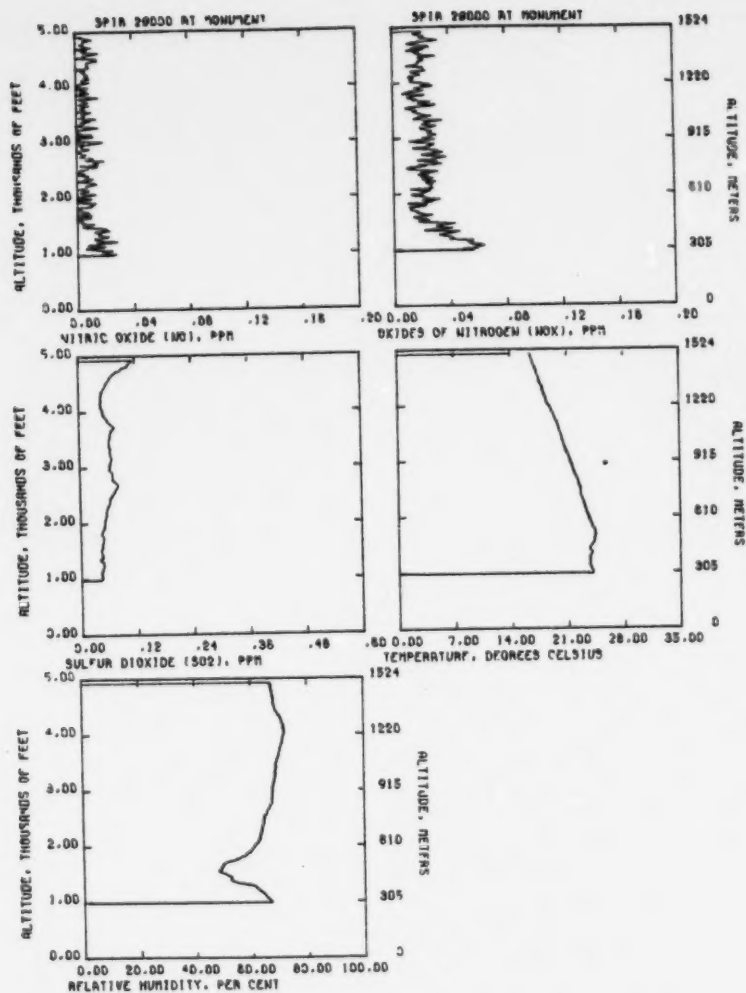
BEGIN
FIRST
LINE OF
TEXT
HERE

TYPING GUIDE SHEET

CENTER
OF PAGE

TOP OF
IMAGE
AREA

DROPPED
HEAD
BEGIN
SECTION
HERE



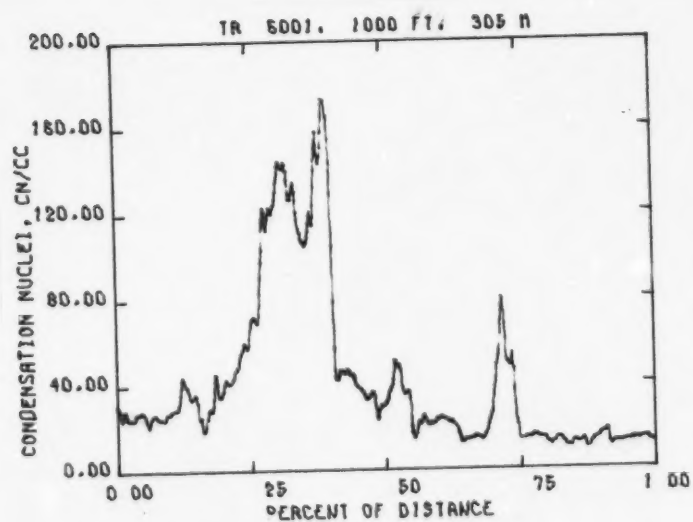
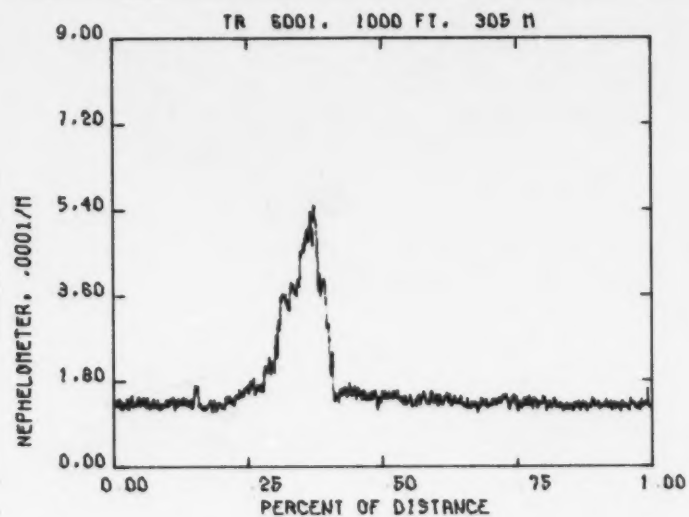
BEGIN
LAST LINE
OF TEXT

3/8"

BOTTOM OF
IMAGE AREA
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUSTRATIONS

TR. 6001, 1000 FT, 305 M. CLEAR LAKE TO FLYING F

7/20/74. 10:25:30 TO 10:38:48. DISTANCE= 46.9 KM



BEGIN
LAST LINE
OF TEXT

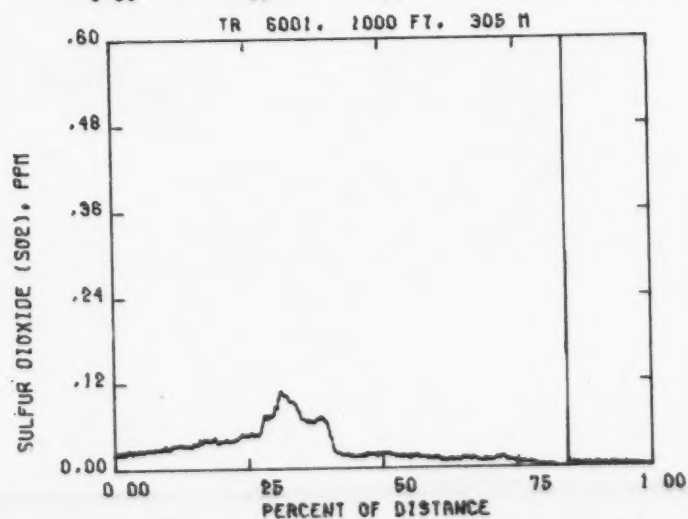
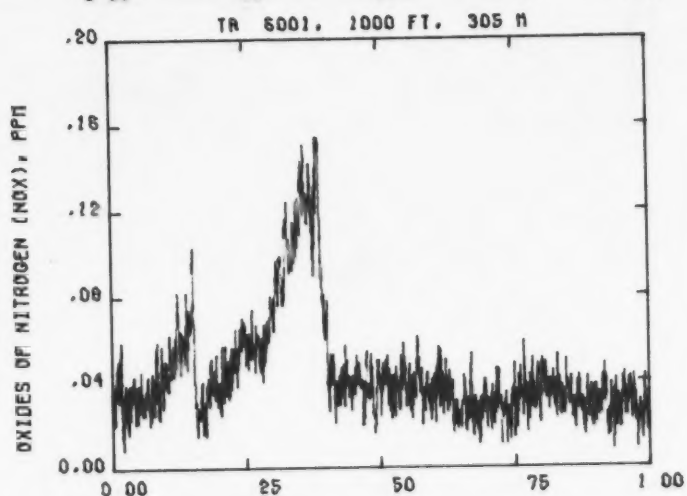
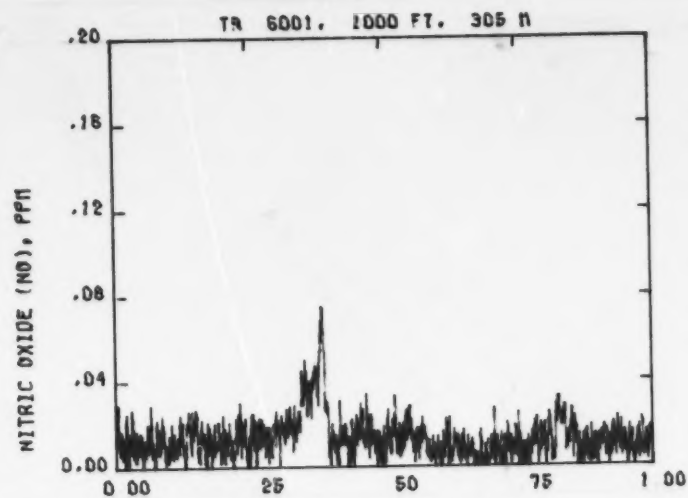
3/8"

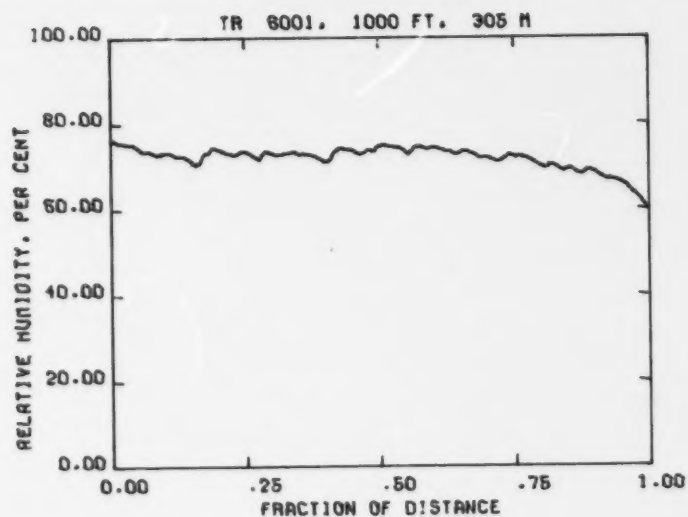
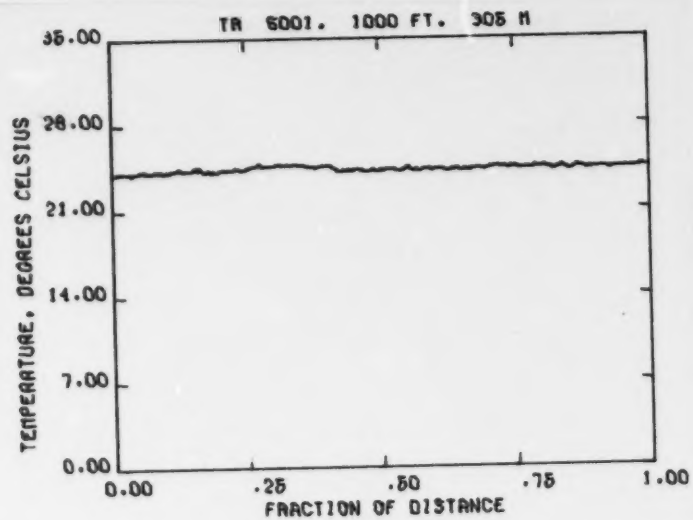
68

PAGE NUMBER

EPA-287 (Cin.)
(4-76)

IMAGE AREA
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUS-
TRATIONS





BEGIN
LAST LINE
OF TEXT

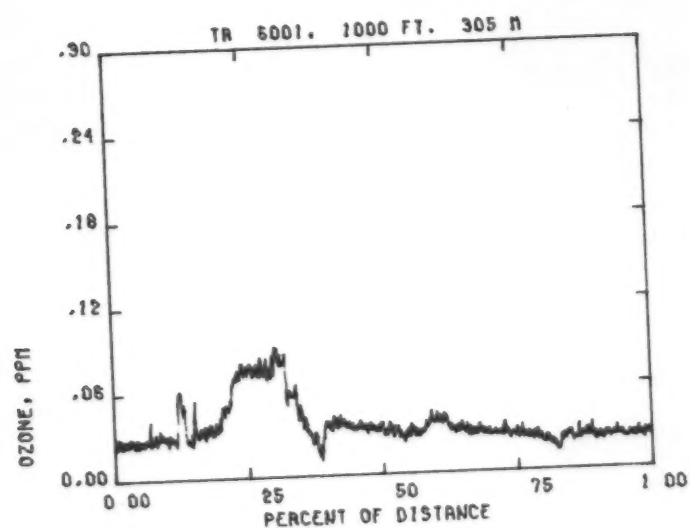
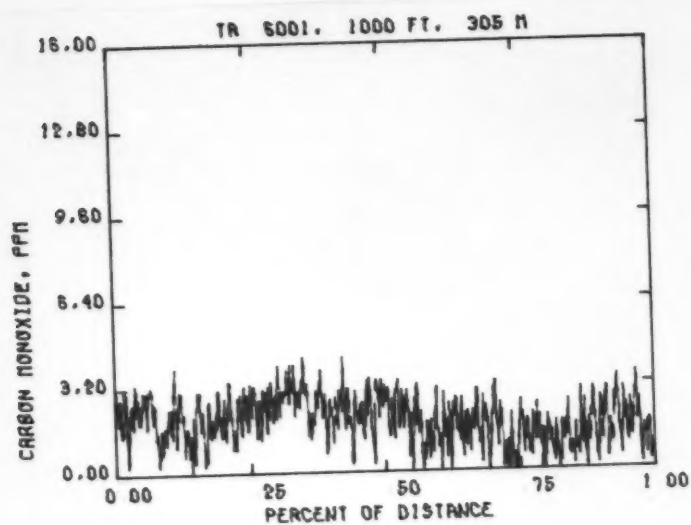
3/8"

70

PAGE NUMBER

EPA-257 (Chs.)
(4-75)

BOTTOM OF
IMAGE AREA:
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUS-
TRATIONS



BEGIN
LAST LINE
OF TEXT

3/8"

71

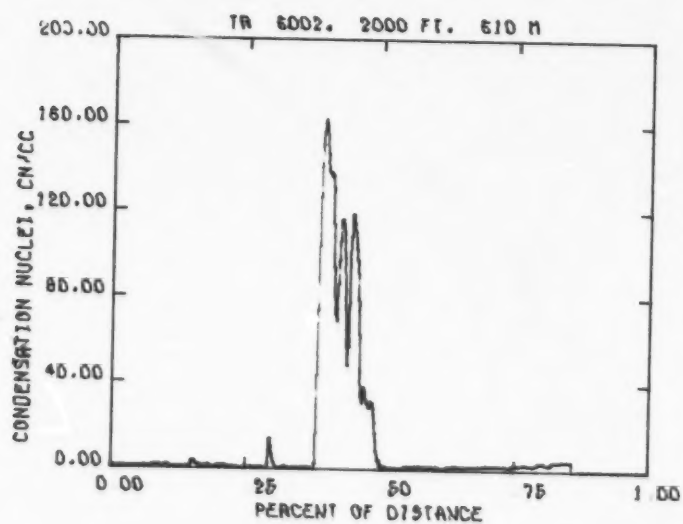
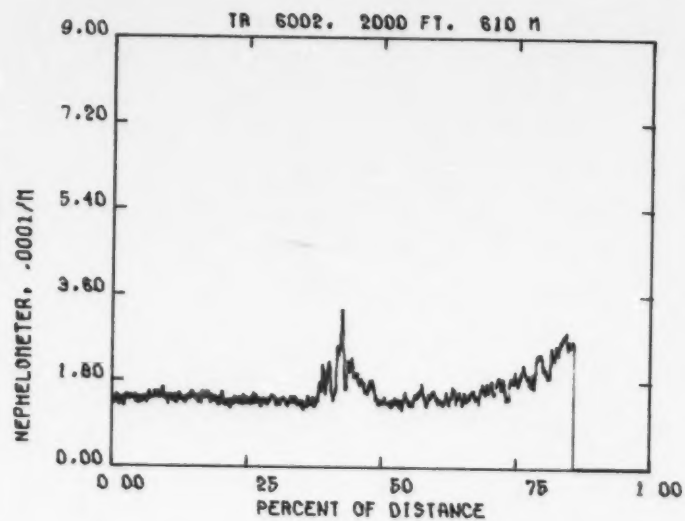
PAGE NUMBER

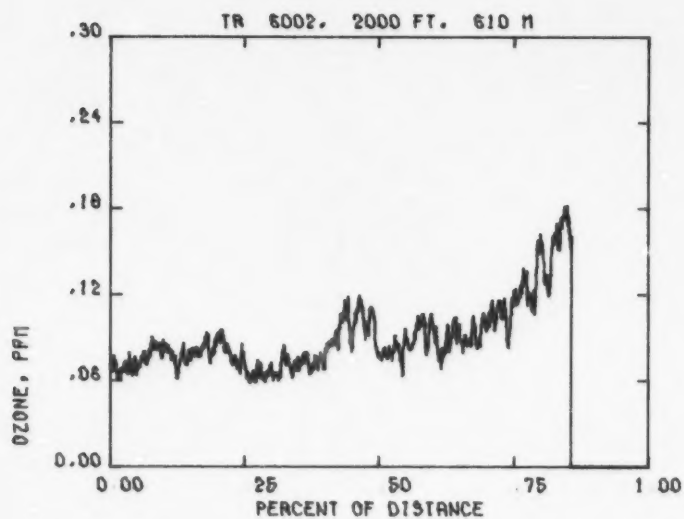
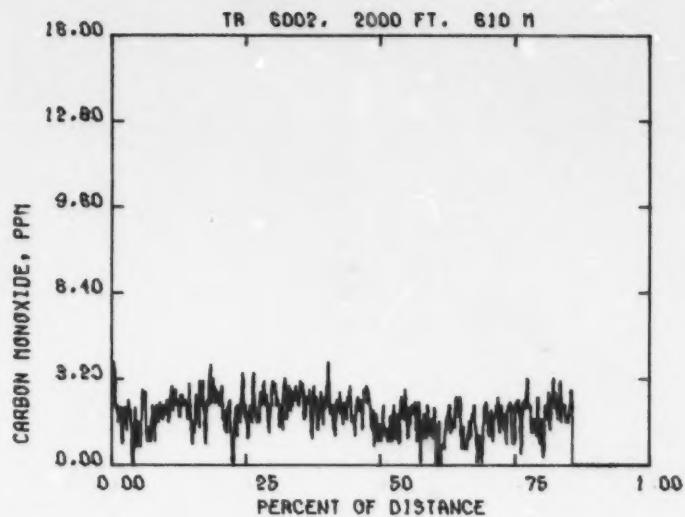
EPA-287 (Cln.)
(4-76)

BOTTOM OF
IMAGE AREA
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUSTRATIONS

TR. 6002. 2000 FT. 610 M, CLEAR LAKE TO FLYING F

7/20/74. 10:42:16 TO 10:52:3. DISTANCE= 46.9 KM





BEGIN
LAST LINE
OF TEXT

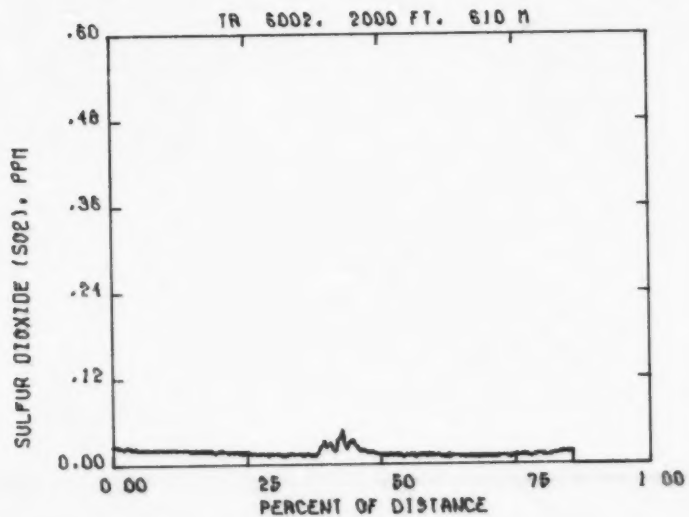
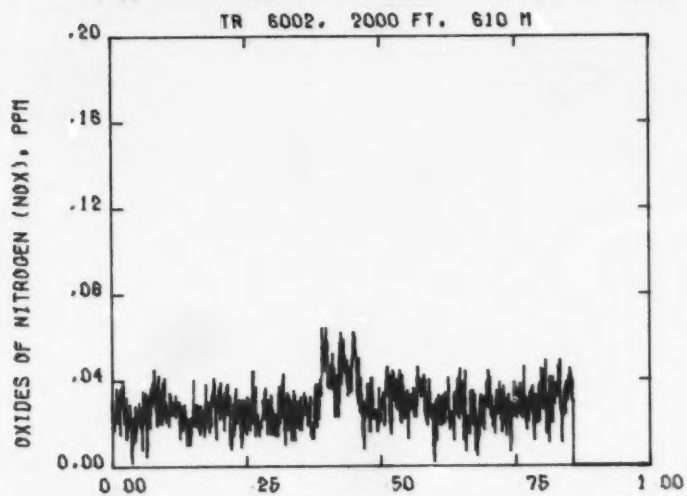
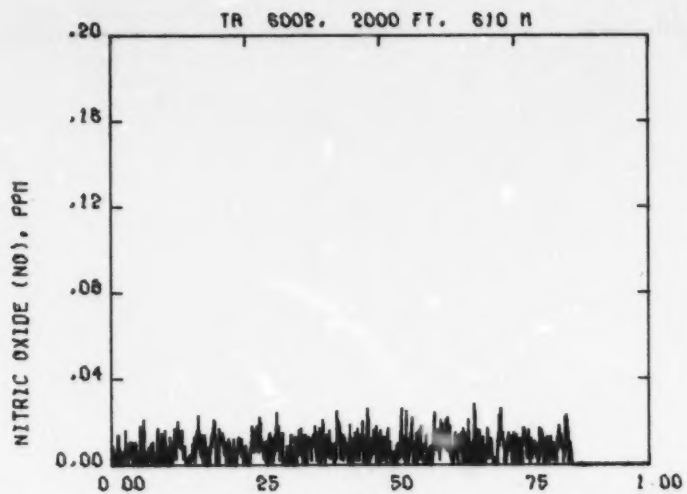
3/8"

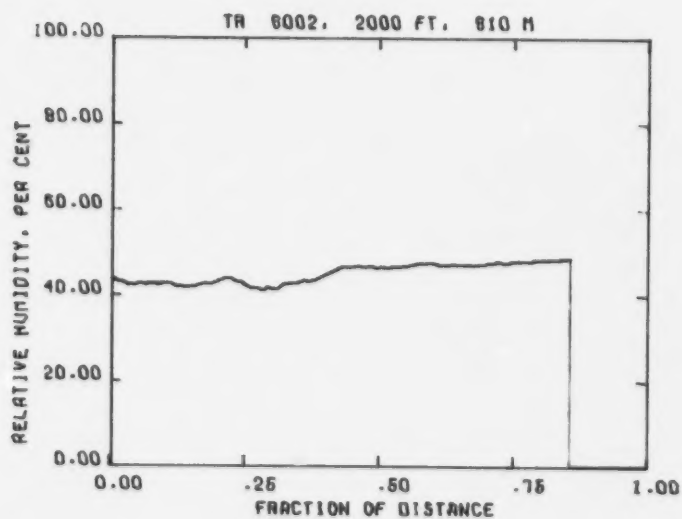
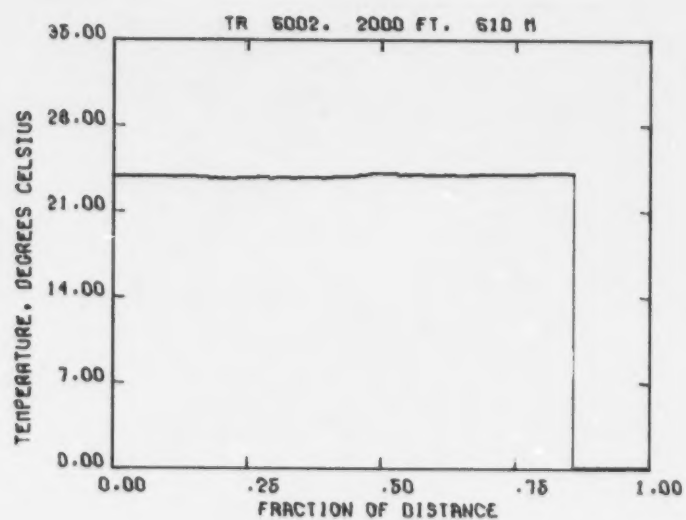
EPA-287 (C(n.)
(4-76)

73

PAGE NUMBER

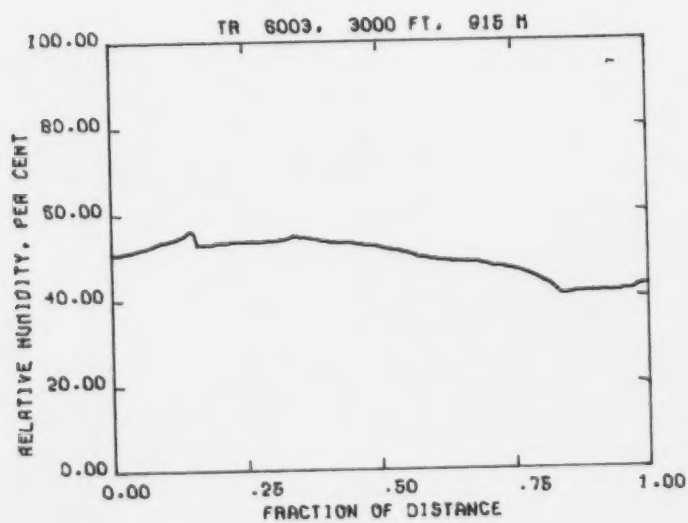
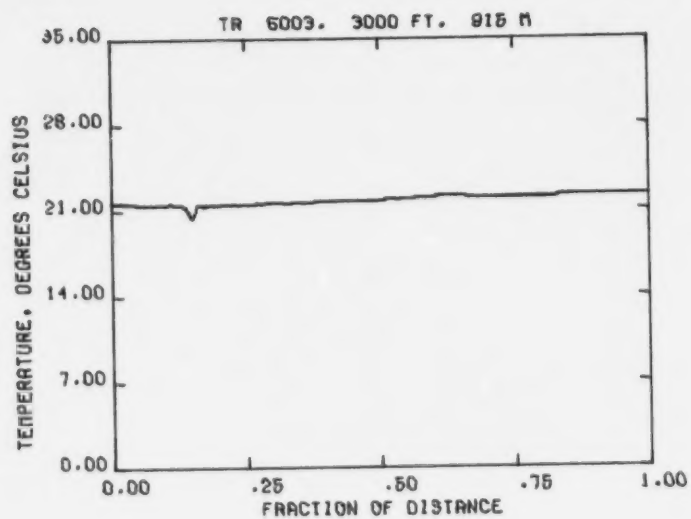
BOTTOM OF
IMAGE AREA,
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUS-
TRATIONS





FROM
30° LINE
OF TEXT

BOTTOM OF
IMAGE AREA,
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUS-
TRATIONS



BELOW
LAST LINE
OF TEXT

2 1/8"

76

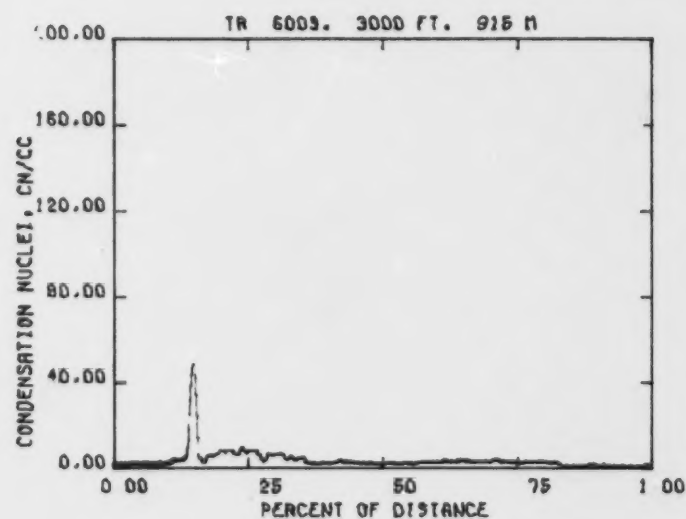
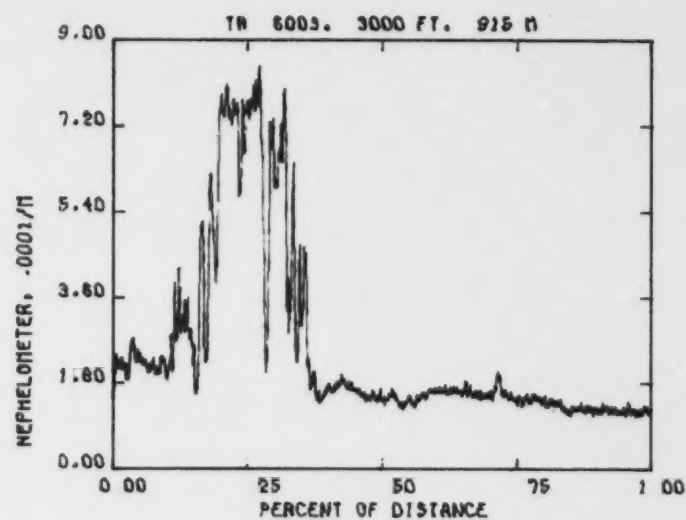
PAGE NUMBER

EPA-267 (CIB-1)
(4-75)

DO NOT
WASTE AREA
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUS-
TRATIONS

TR. 6003. 3000 FT. 915 M, CLEAR LAKE TO FLYING F

7/20/74, 11:24.5 TO 11:15.33, DISTANCE= 46.9 KM



BEGIN
LAST LINE
OF TEXT

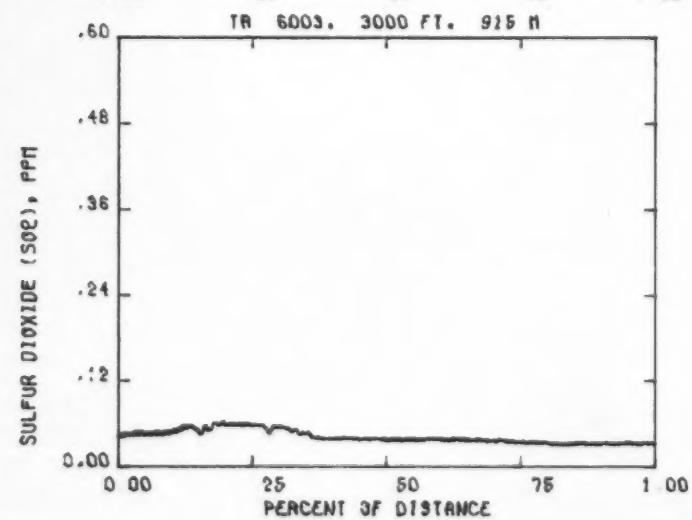
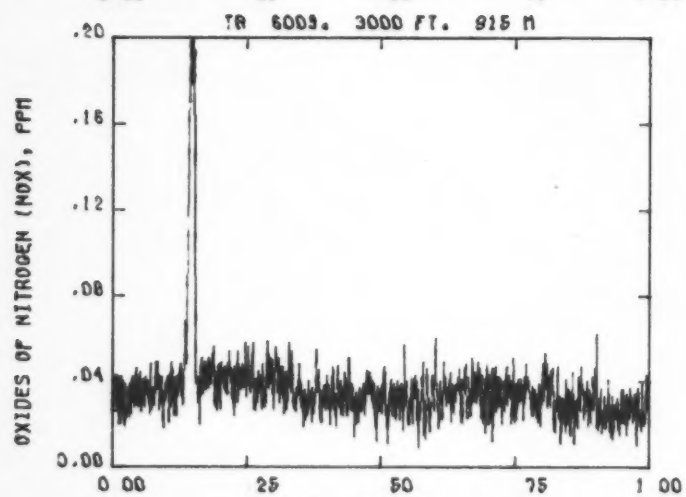
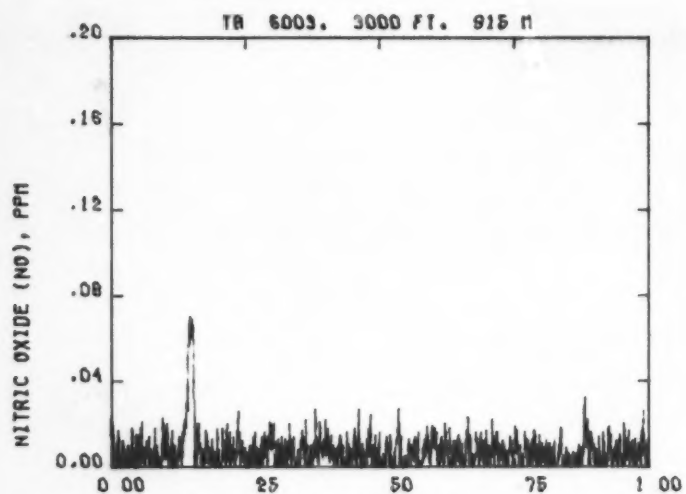
3/8"

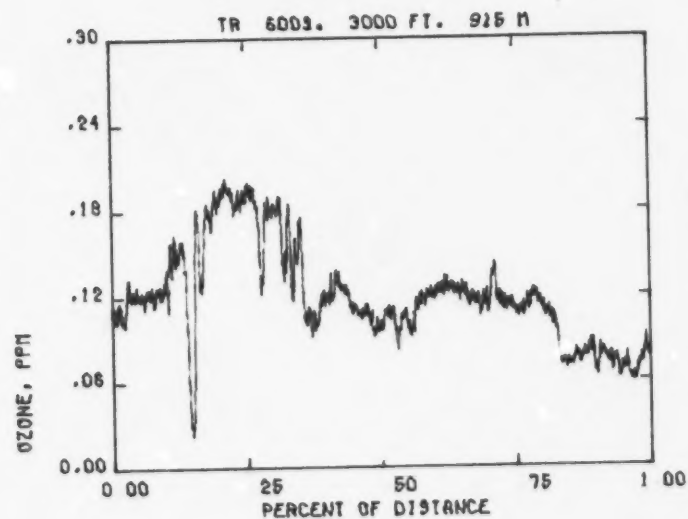
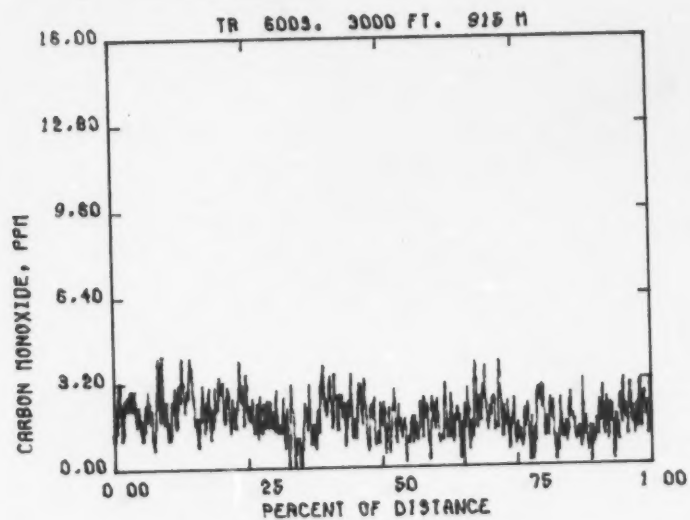
77

PAGE NUMBER

EPA-287 (Cir.)
(8-76)

IMAGE AREA
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUS-
TRATIONS





WELSH
LAST LINE
OF TEXT

3/8"

79

PAGE NUMBER

EPA-207 (C11)
(3-70)

BUILING UP
IMAGE AREA.
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUS-
TRATIONS

BEGIN
FIRST
LINE OF
TEXT
HERE

TYPING GUIDE SHEET

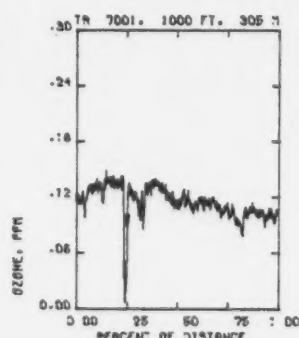
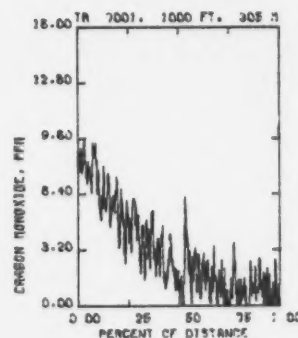
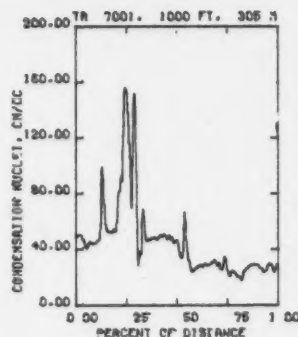
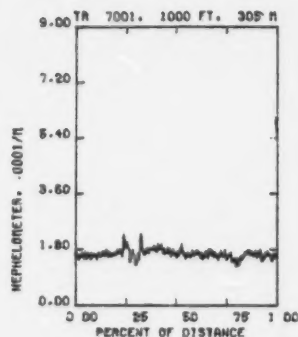
CENTER
OF PAGE

TOP OF
IMAGE
AREA

DROPPED
HEAD
BEGIN
SECTIONS
HERE

TR. 7001. 1000 FT. 305 M. HOBBY TO DYERS INTERSECTION

7/20/74. 13.40.34 TO 13.50.45. DISTANCE= 26.9 KM



BEGIN
LAST LINE
OF TEXT

BOTTOM OF
IMAGE AREA
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUSTRATIONS

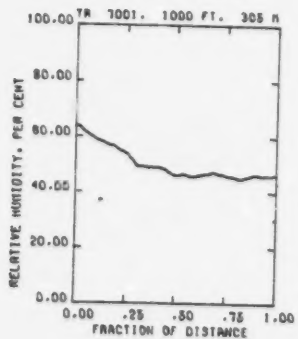
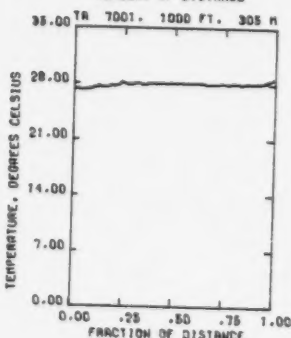
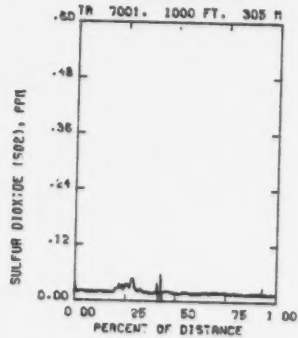
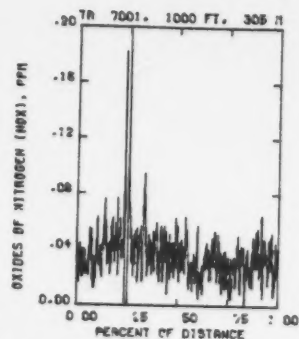
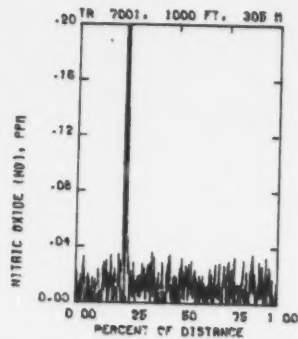
BEGIN
FIRST
LINE OF
TEXT
HERE

TYPING GUIDE SHEET

CENTER
OF PAGE

TOP OF
IMAGE
AREA

DROPPED
HEAD;
BEGIN
SECTIONS
HERE



BEGIN
LAST LINE
OF TEXT

TOP OF
PAGE AREA
BOTTOM
PAGE AREA

BEGIN
FIRST
LINE OF
TEXT
HERE

TYPING GUIDE SHEET

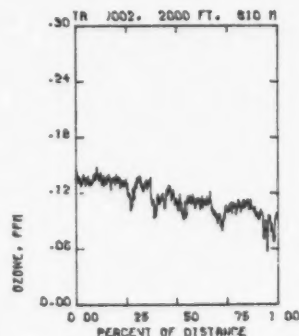
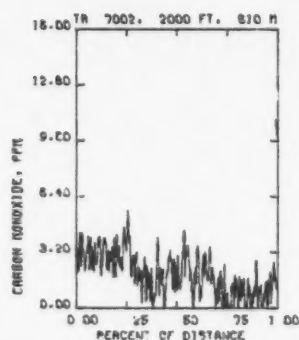
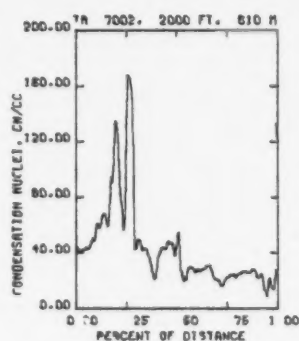
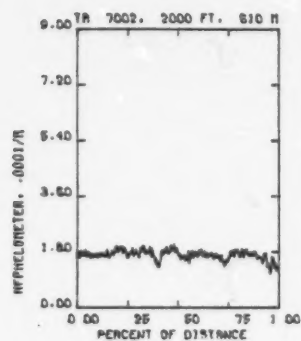
CENTER
OF PAGE

TOP OF
IMAGE
AREA

DROPPED
HEAD
BEGIN
SECTIONS
HERE

TR. 7002. 2000 FT. 810 M. HOBBY TO DYERS INTERSECTION

7/20/74. 13:53:21 TO 14:00:12. DISTANCE= 26.9 KM



BEGIN
LAST LINE
OF TEXT

BOTTOM OF
IMAGE AREA
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUSTRATIONS

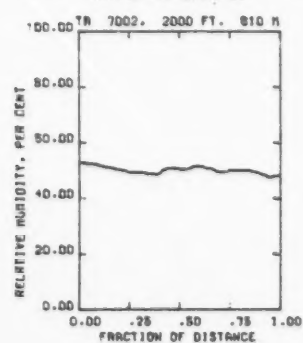
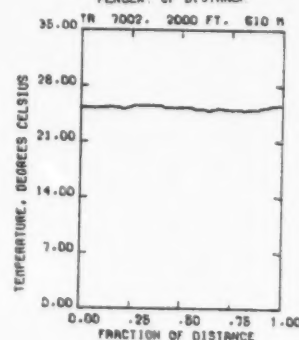
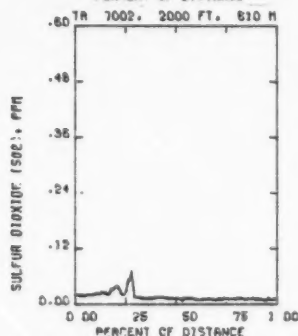
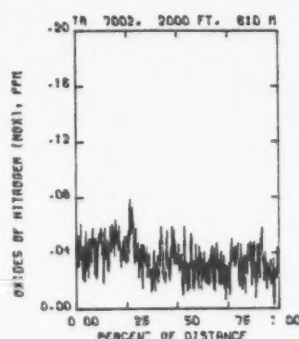
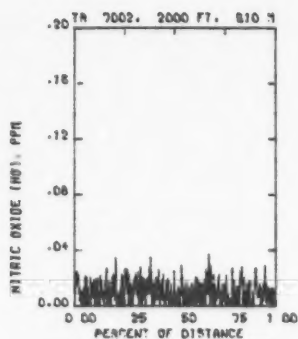
BEGIN
FIRST
LINE OF
TEXT
HERE

TYPING GUIDE SHEET

CENTER
OF PAGE

TOP OF
IMAGE
AREA

DROPPED
HEAD;
BEGIN
SECTIONS
HERE



BEGIN
LAST LINE
OF TEXT

TOP OF
IMAGE AREA
DIMENSION
FOR TABLES
AND FIGURES

BEGIN
FIRST
LINE OF
TEXT
HERE

TYPING GUIDE SHEET

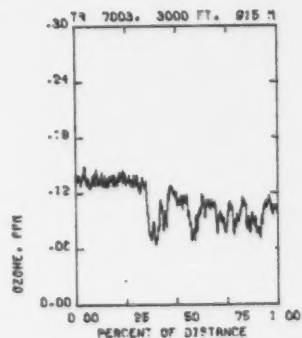
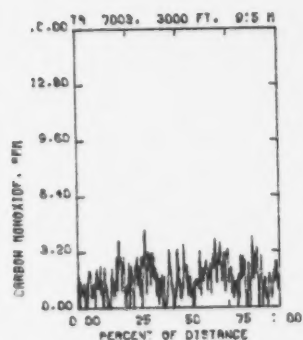
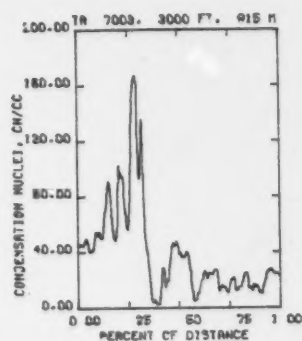
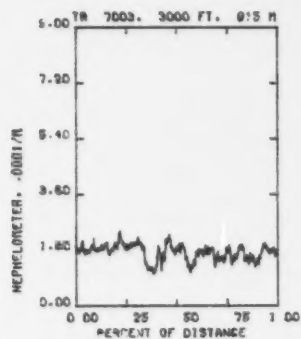
CENTER
OF PAGE

TOP OF
IMAGE
AREA

DROPPED
HEAD:
BEGIN
SECTIONS
HERE

TR. 7003. 3000 FT. 915 M. HOBBY TO DYERS INTERSECTION

7/20/74. 14:23.7 TO 14:29.64. DISTANCE= 26.9 KM



BEGIN
LAST LINE
OF TEXT

3/8"

BOTTOM OF
IMAGE AREA
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUSTRATIONS

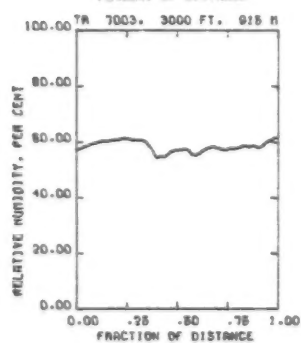
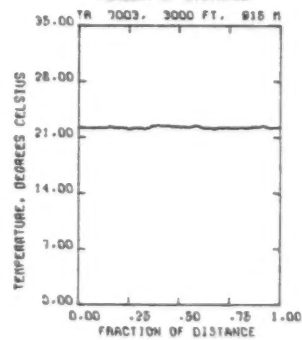
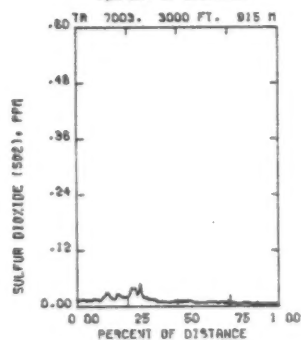
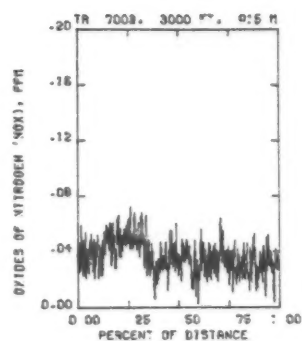
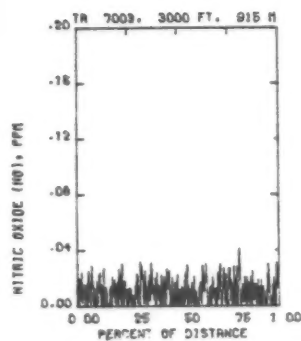
BEGIN
FIRST
LINE OF
TEXT
HERE

TYPING GUIDE SHEET

CENTER
OF PAGE

TOP OF
IMAGE
AREA

DROPPED
HEAD
BEGIN
SECTIONS
HERE



BEGIN
LAST LINE
OF TEXT

FROM TOP
IMAGE AREA
OUTLINE
DIMENSIONS
FOR TABLE
AND PLOT
TRACING

BEGIN
FIRST
LINE OF
TEXT
HERE

TYPING GUIDE SHEET

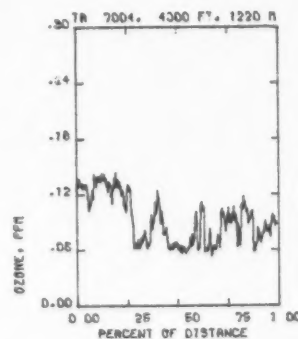
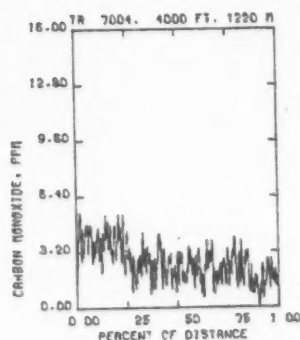
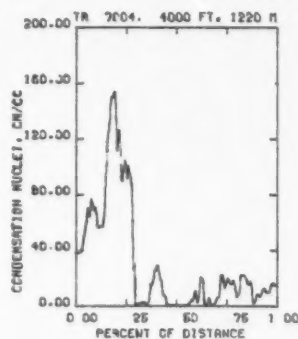
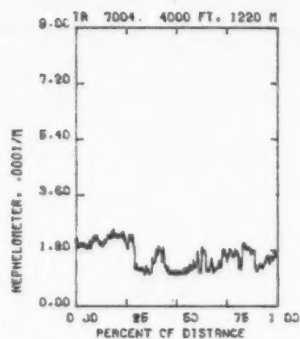
CENTER

TOP OF
IMAGE
AREA

DROPPED
HEAD;
BEGIN
SECTIONS
HERE

TR. 7004, 4000 FT, 1220 M, HOBBY TO DYERS INTERSECTION

7/20/74, 14.12.10 TO 14.18.44, DISTANCE= 26.9 KM



BEGIN
LAST LINE
OF TEXT

BOTTOM OF
IMAGE AREA
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUSTRATIONS

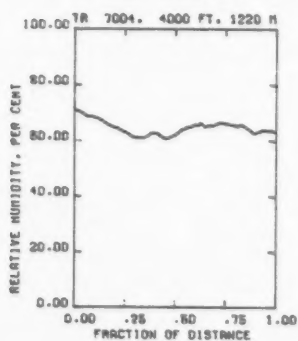
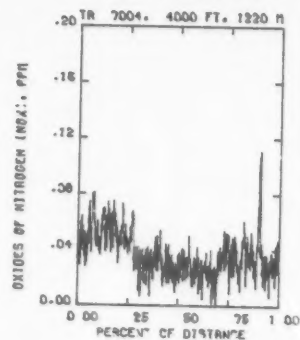
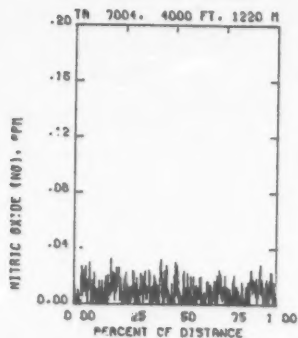
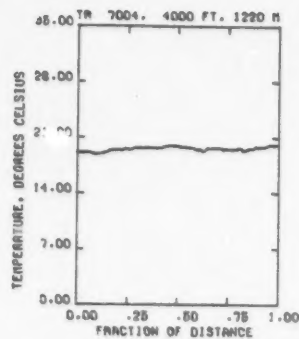
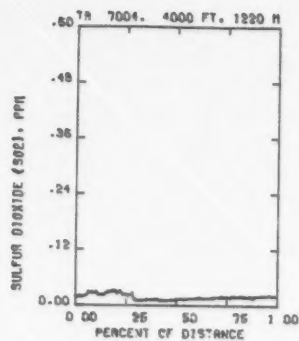
BEGIN
FIRST
LINE OF
TEXT
HERE

TYPING GUIDE SHEET

CENTER
OF PAGE

TOP OF
IMAGE
AREA

DROPPED
HEAD,
BEGIN
SECTIONS
HERE

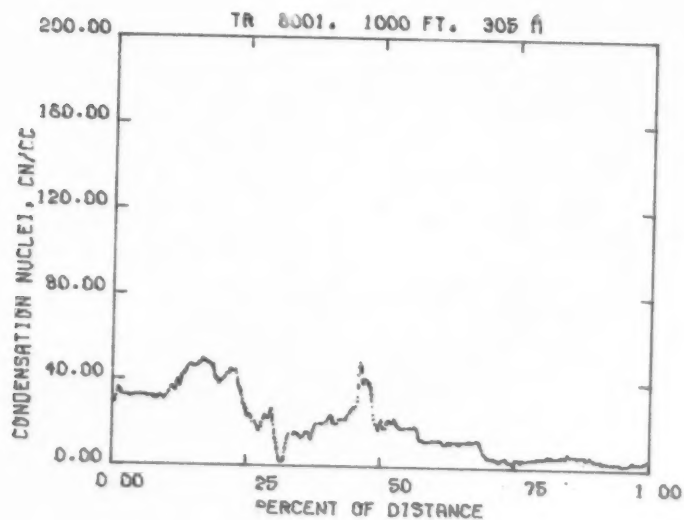
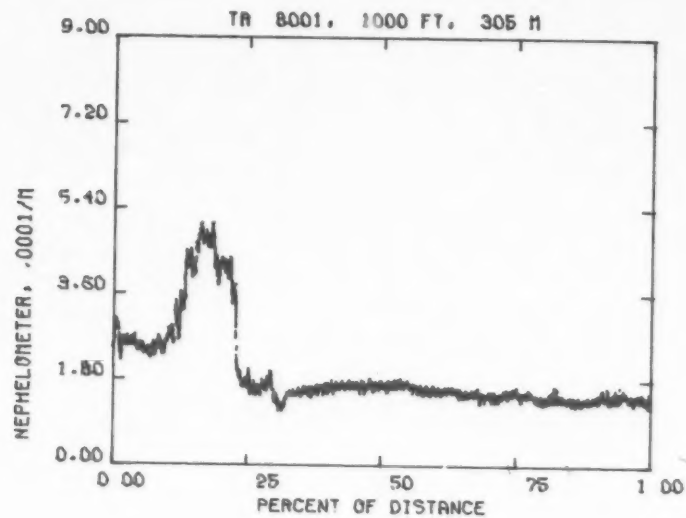


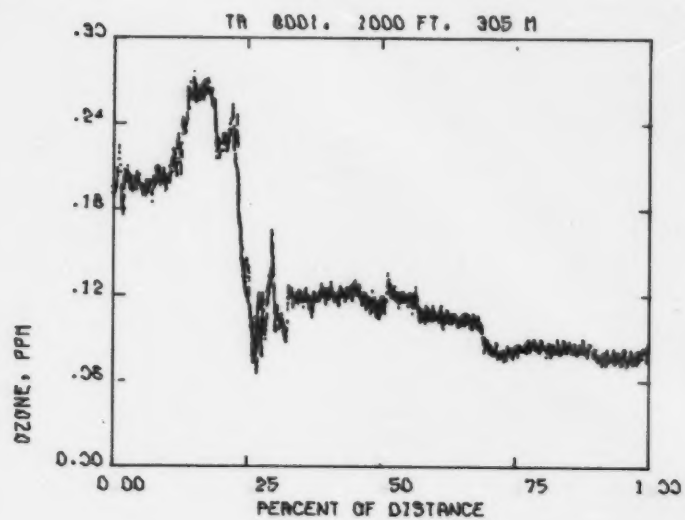
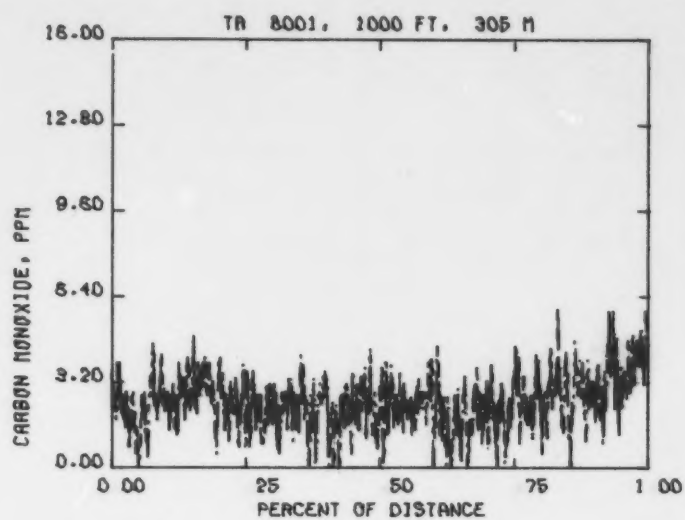
BEGIN
LAST LINE
OF TEXT

LOCATE
LINE AREA
LINES
SECTION
PER TABLE
AND UNIT
DISTANCE

TR. 8001. 1000 FT. 305 M. CLEAR LAKE TO FLYING F

7/20/74. 14.41.50 TO 14.57.10. DISTANCE= 46.9 KM





BEGIN
LAST LINE
OF TEXT

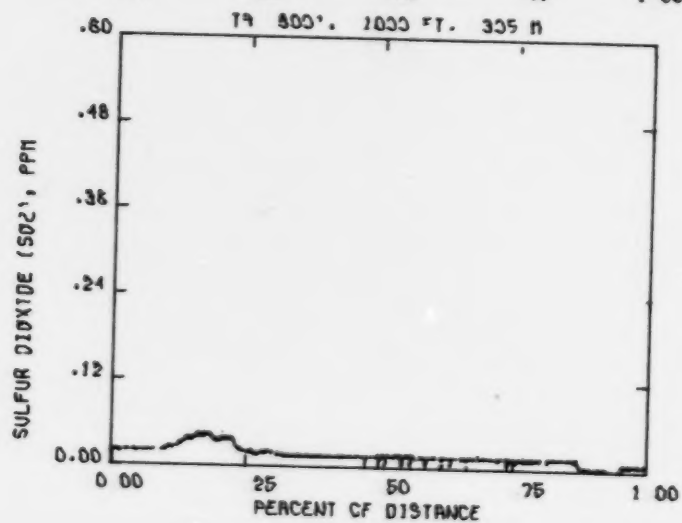
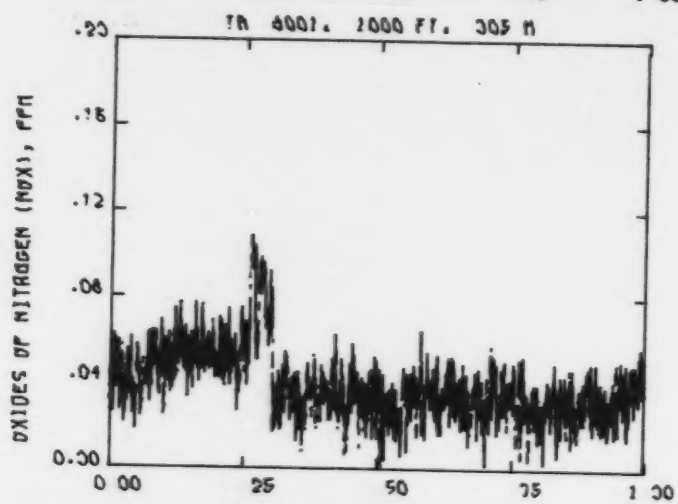
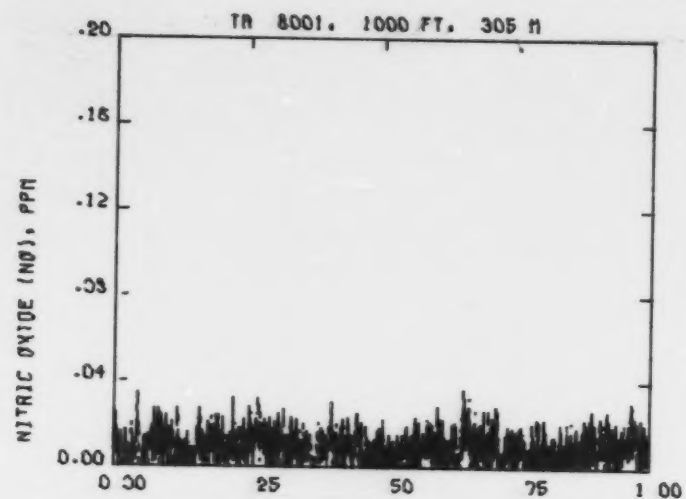
3/8"

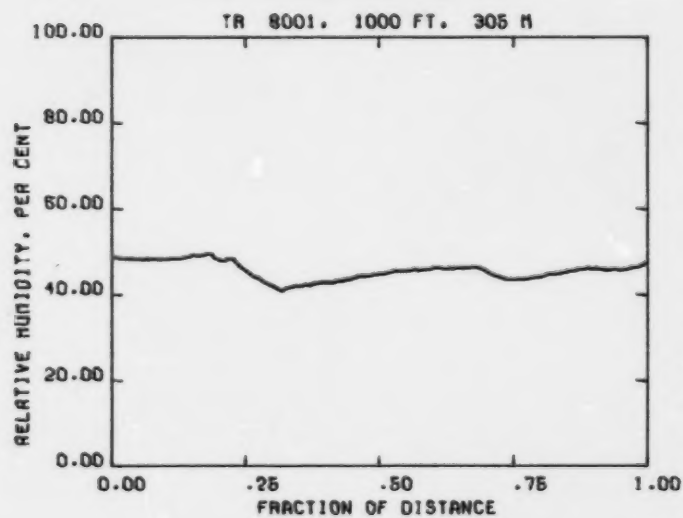
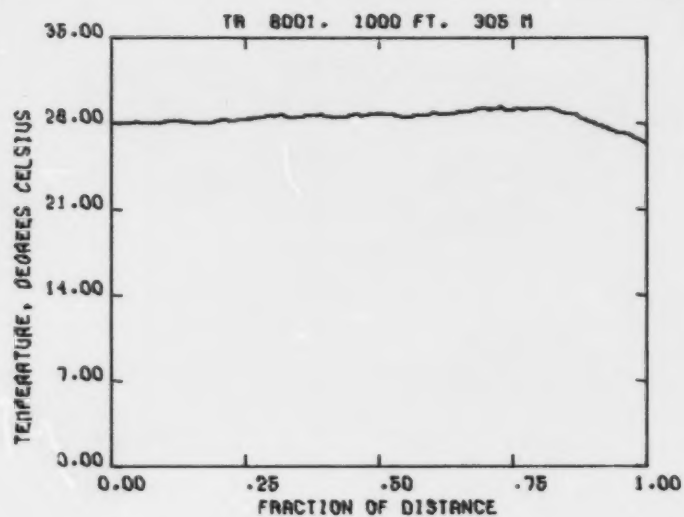
EPA-287 (Cin.)
(4-76)

89

PAGE NUMBER

IMAGE AREA,
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUS-
TRATIONS





LAST LINE
OF TEXT

3/8"

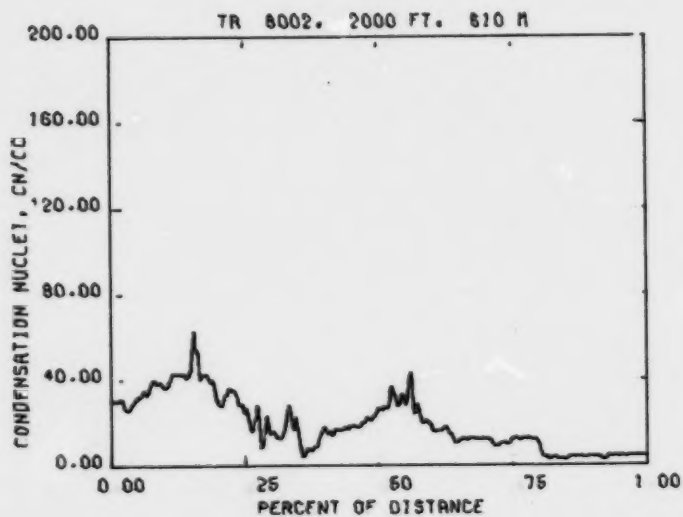
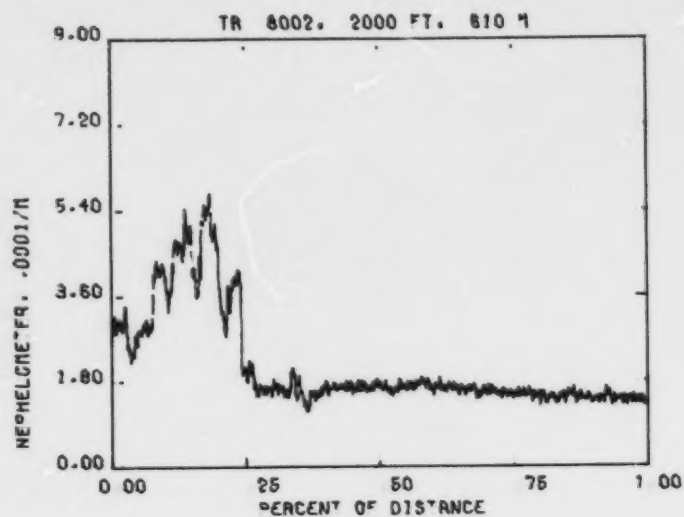
91

PAGE NUMBER

DIMENSION
FOR TABLES
AND ILLUS-
TRATIONS

TR. 8002, 2000 FT. 610 M. CLEAR LAKE TO FLYING F

7/20/74, 14:57:24 TO 15:10:38, DISTANCE= 46.9 KM



BEGIN
LAST LINE
OF TEXT

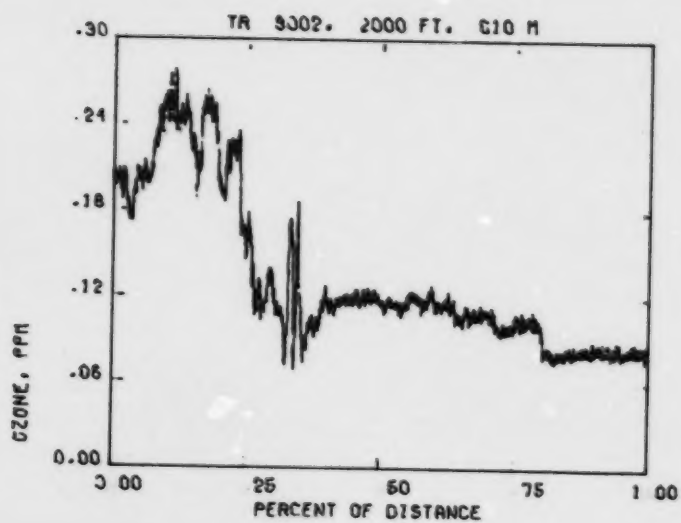
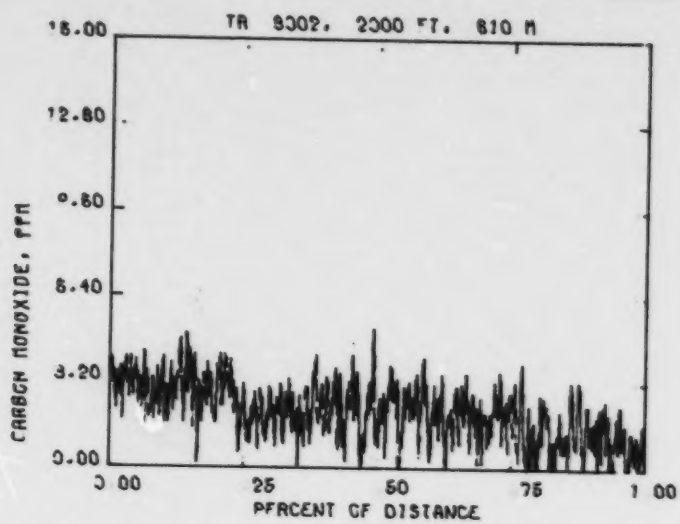
3/8"

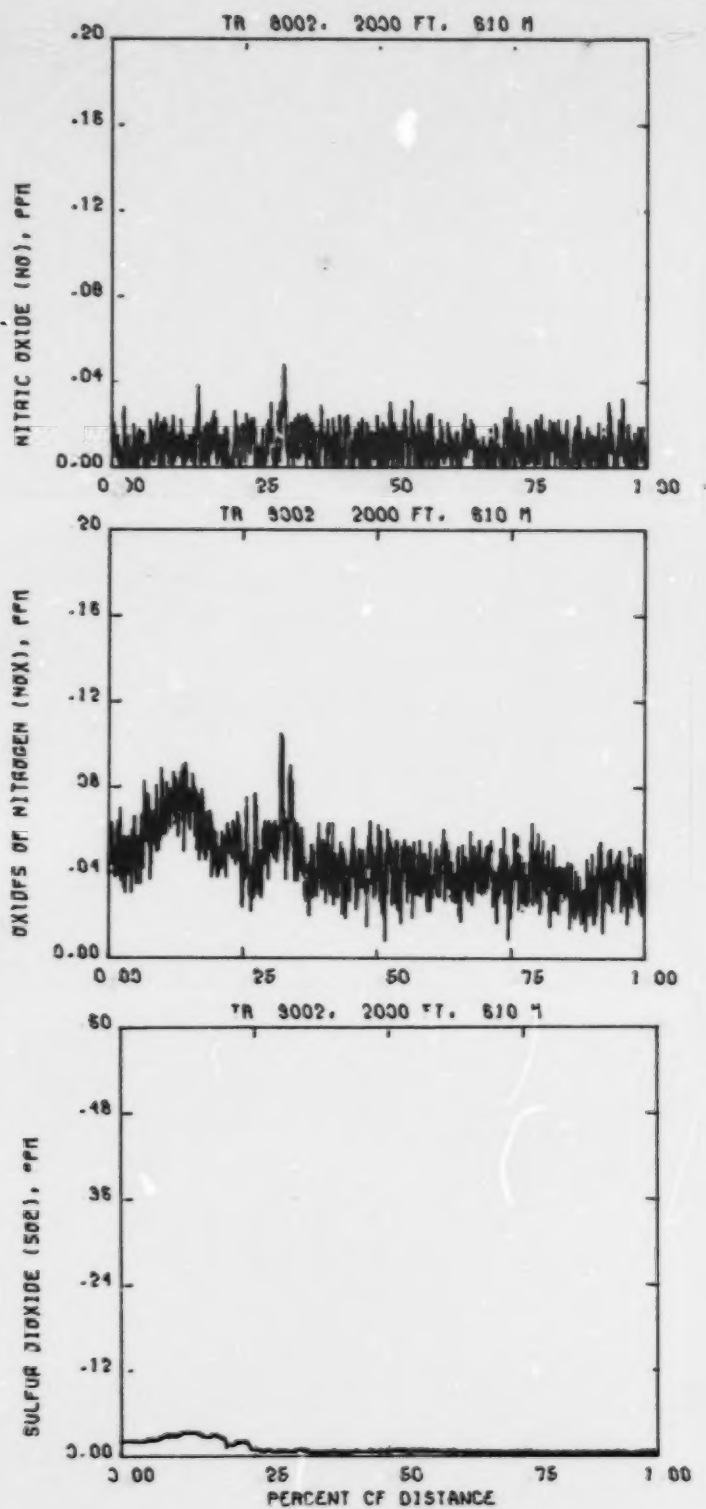
92

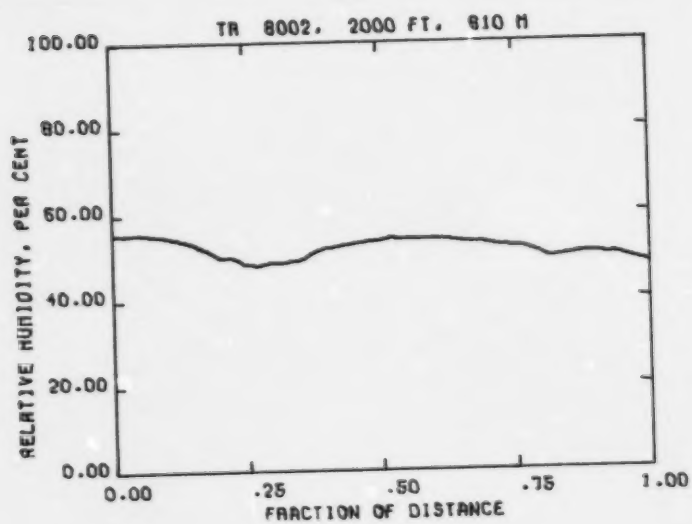
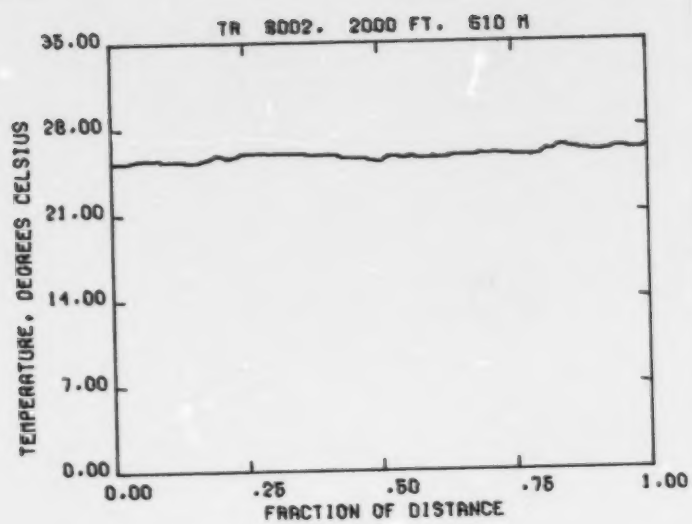
PAGE NUMBER

EPA-287 (Cin.)
(4-76)

BOTTOM OF
IMAGE AREA
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUS-
TRATIONS

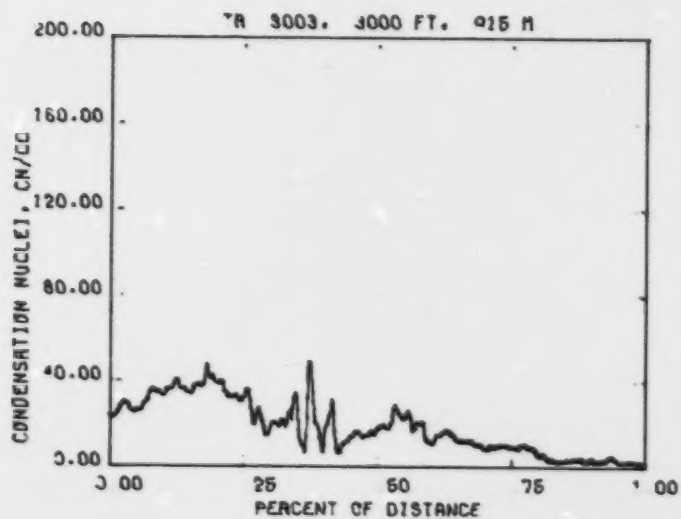
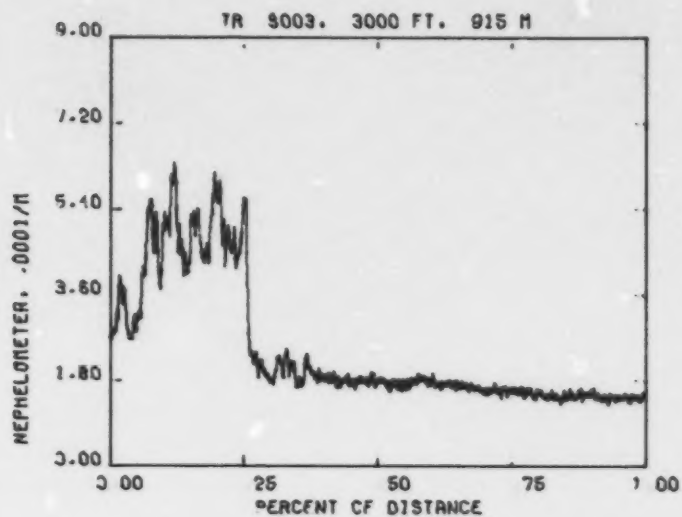


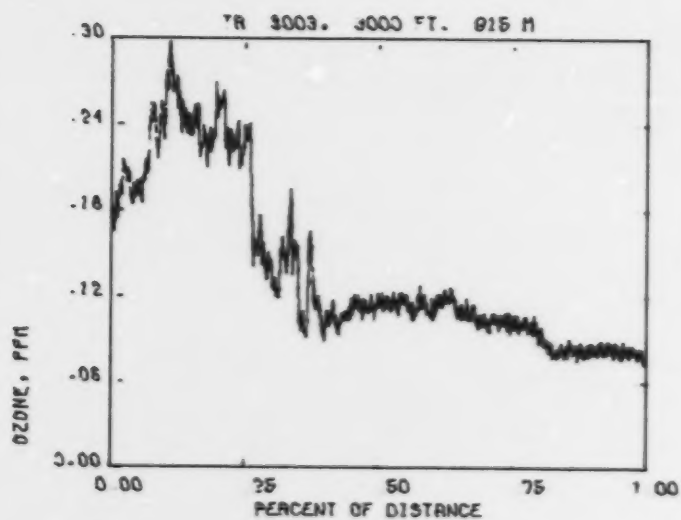
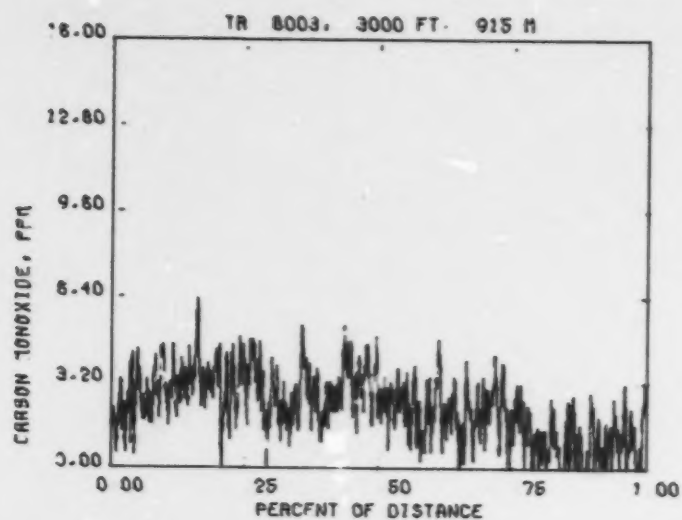


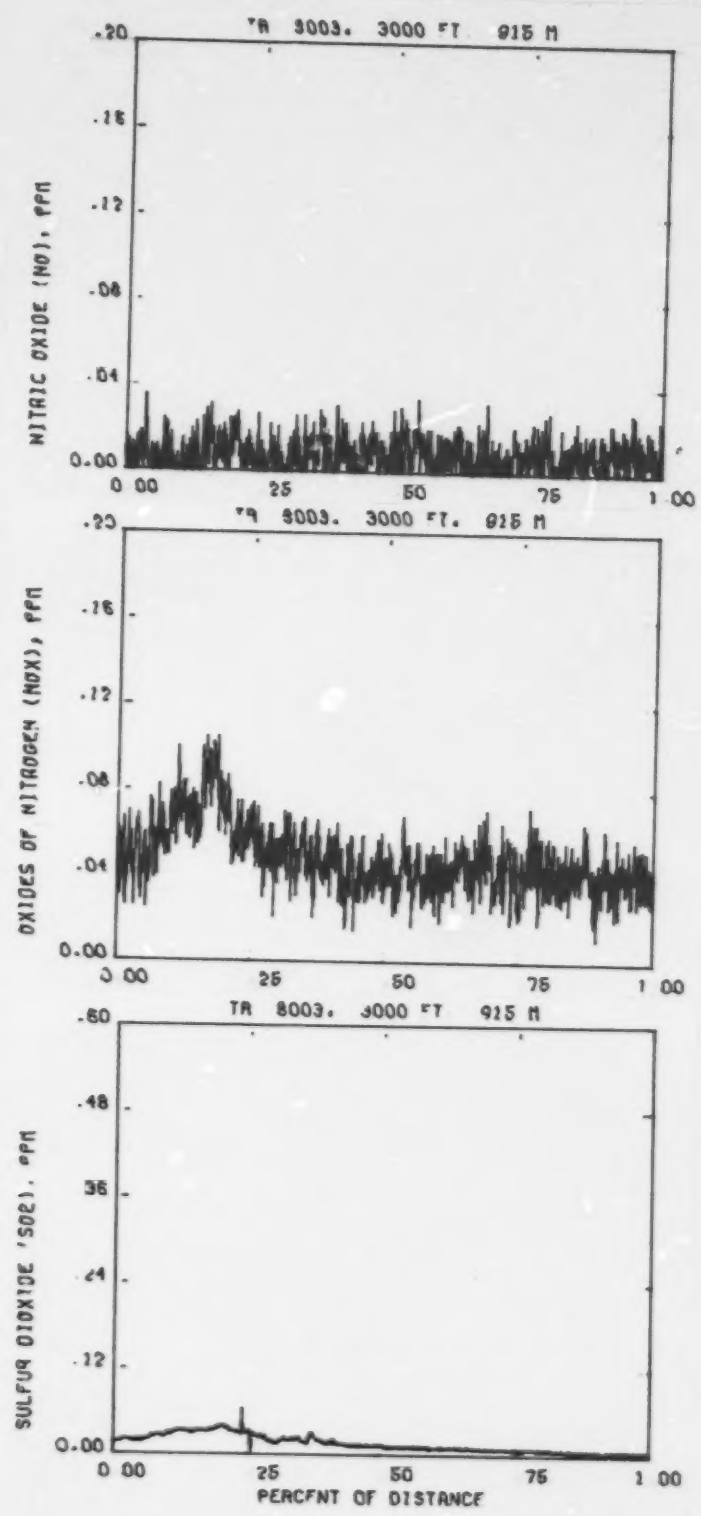


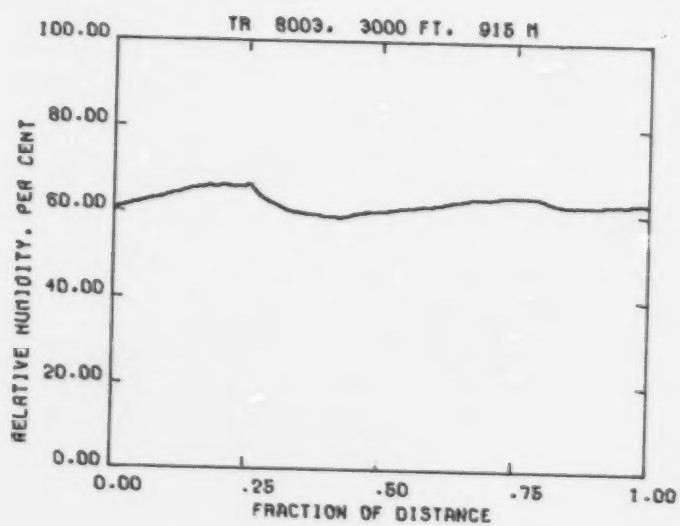
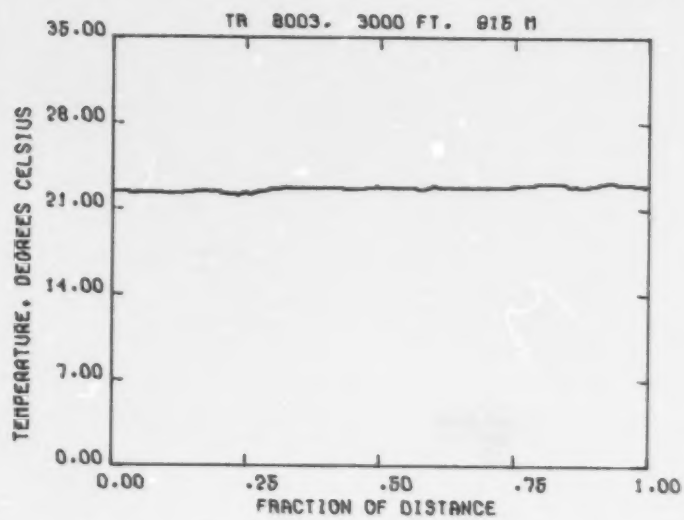
76
TR. 8003. 3000 FT. 915 M. CLEAR LAKE TO FLYING F

7/20/74. 15:13:57 TO 15:27:11. DISTANCE= 46.9 KM





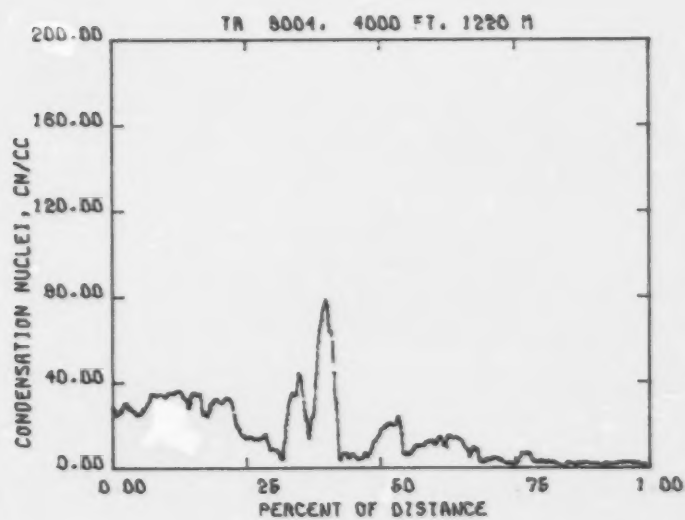
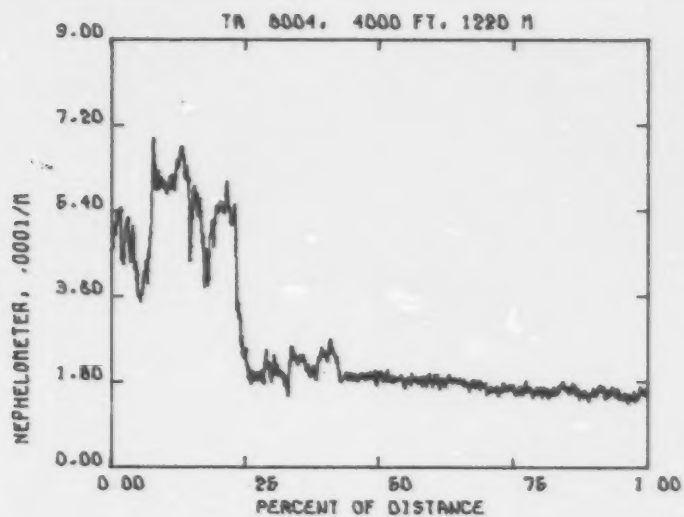


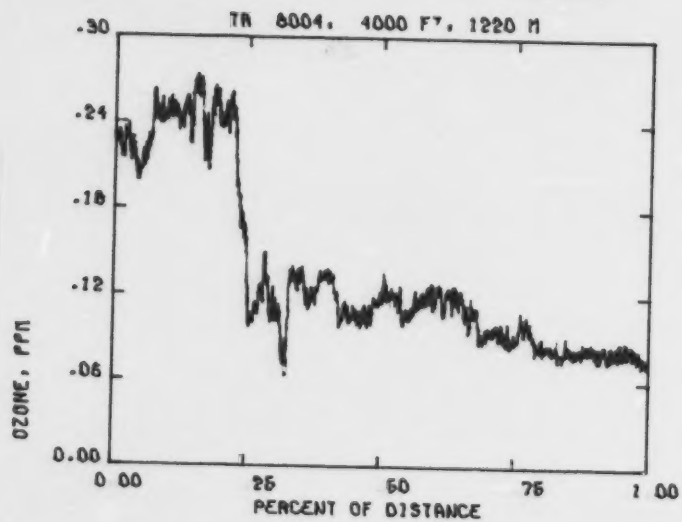
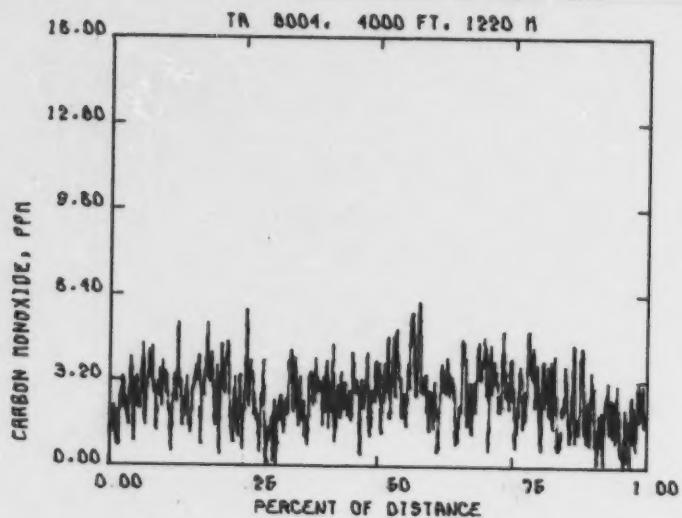


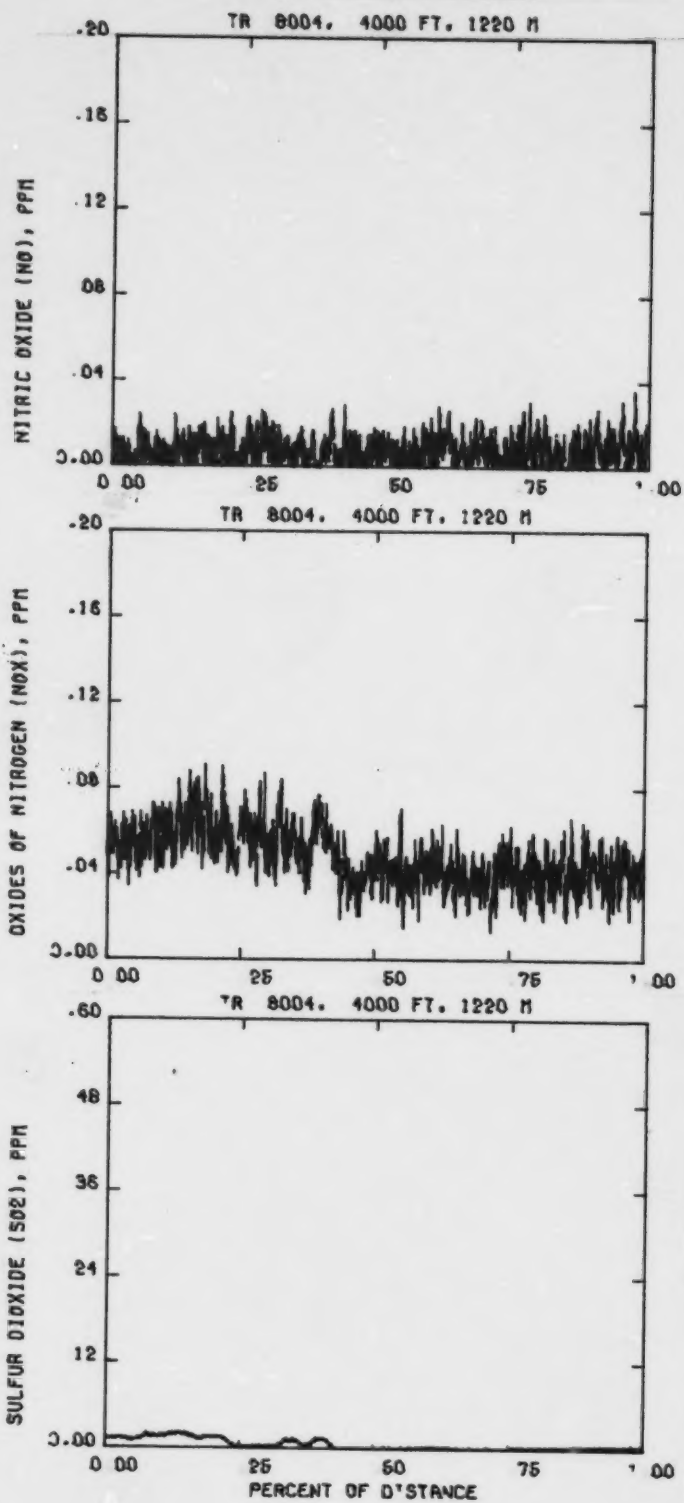
150

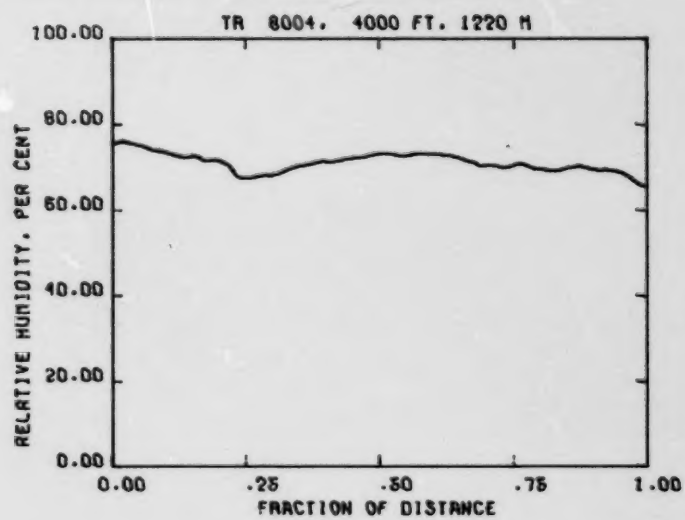
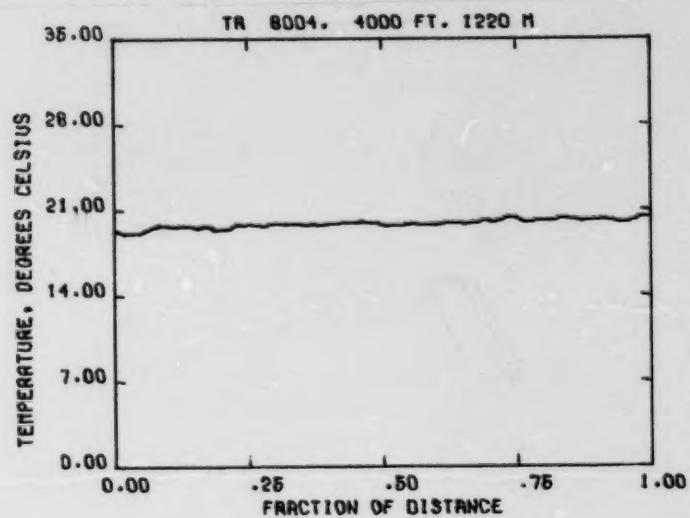
TA. 8004. 4000 FT. 1220 M. CLEAR LAKE TO FLYING F

7/20/74. 15:29:42 TO 15:42:55. DISTANCE= 46.9 KM



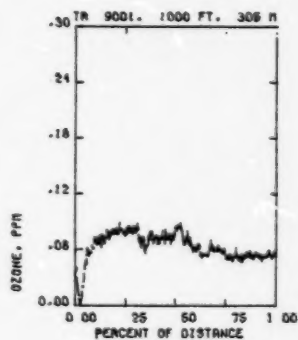
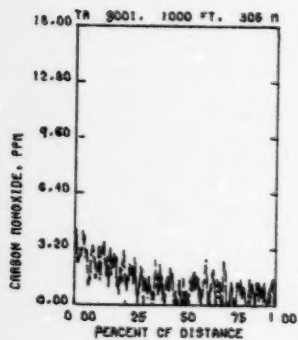
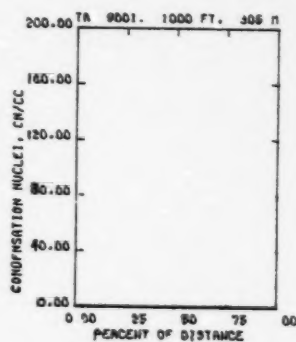
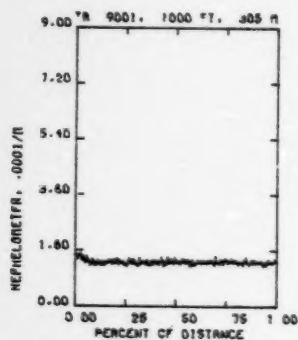


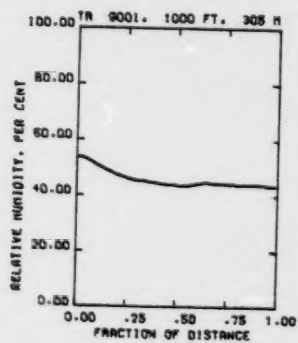
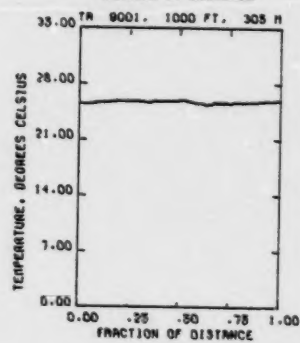
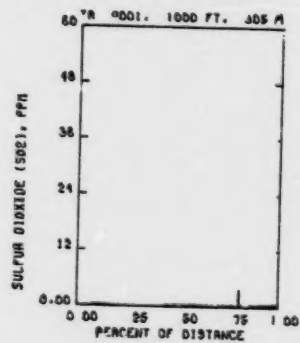
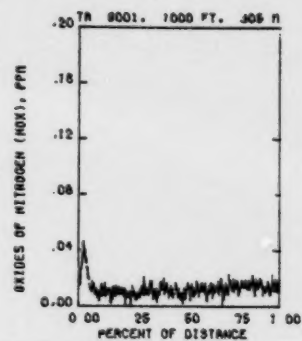
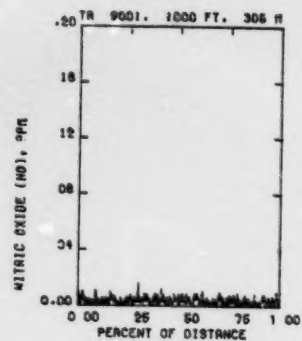




TR. 9001. 1000 FT. 305 M. HOBBY TO DYERS INTERSECTION

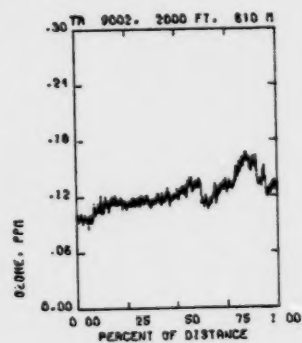
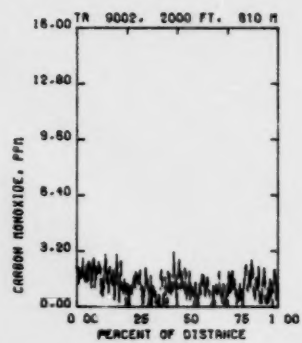
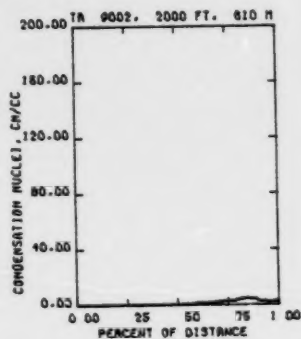
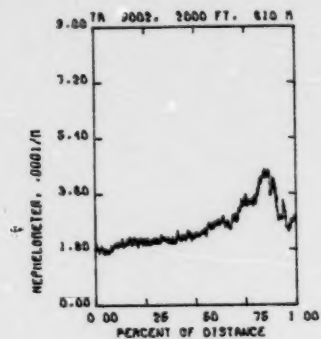
7/21/74. 6:32:36 TO 6:39:12. DISTANCE= 26.9 KM

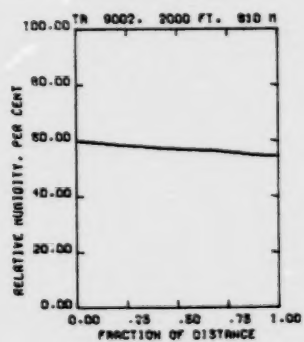
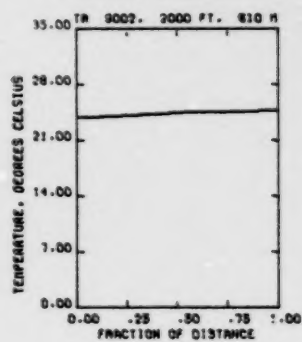
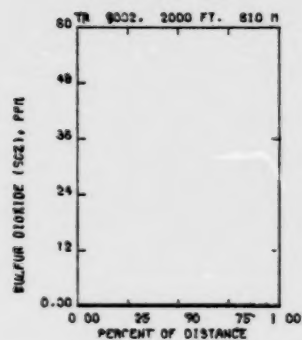
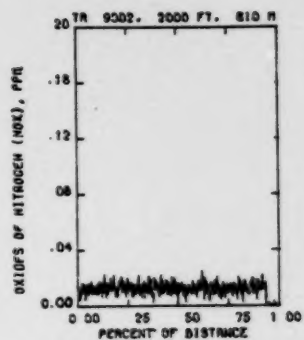
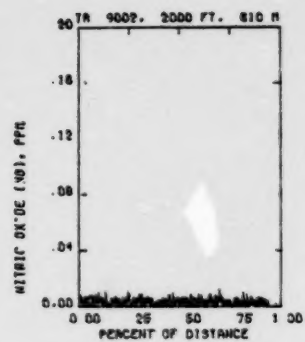




TR. 9002. 2000 FT. 610 M. HOBBY TO DYERS INTERSECTION

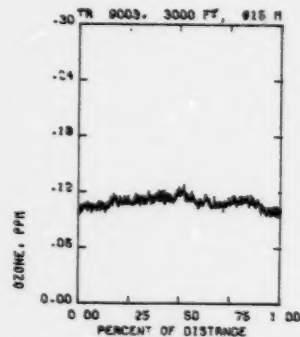
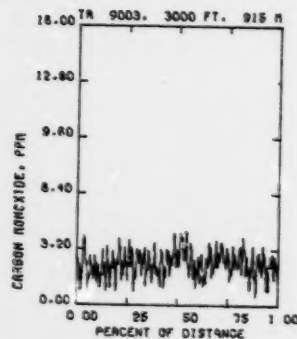
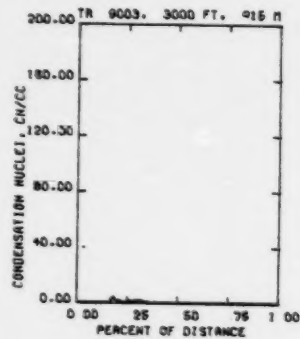
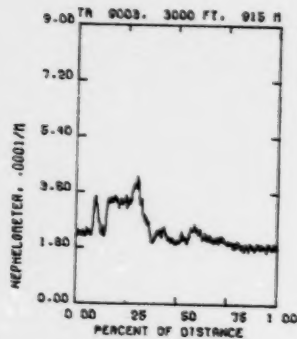
7/21/74. 6:42:47 TO 6:50:21. DISTANCE= 26.9 KM

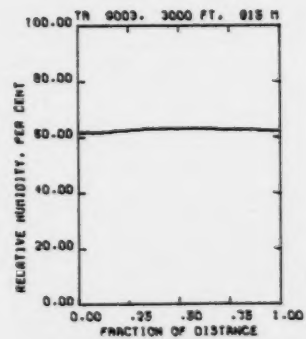
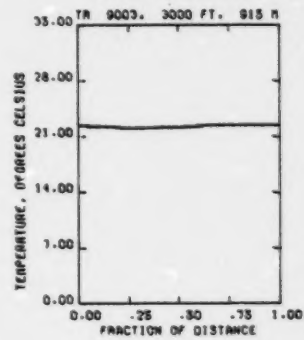
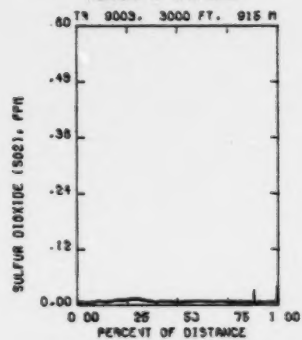
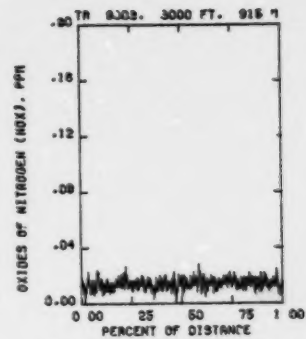
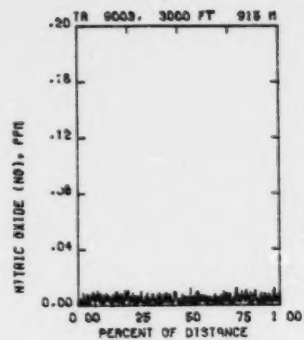




TR. 9003. 3000 FT. 915 M. HOBBY TO DYERS INTERSECTION

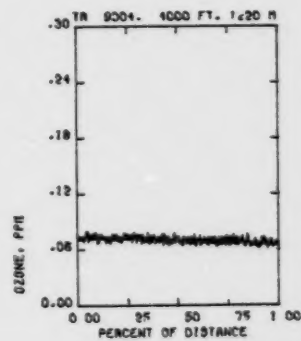
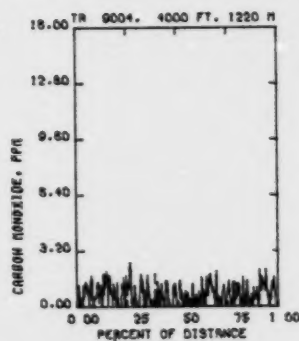
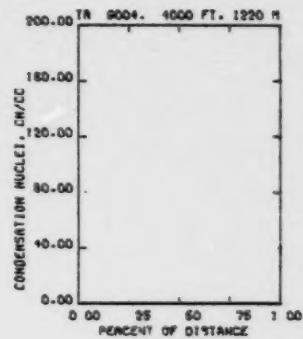
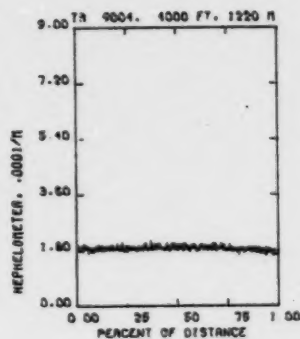
7/21/74. 6:53.11 TO 7:00.25. DISTANCE= 26.9 KM

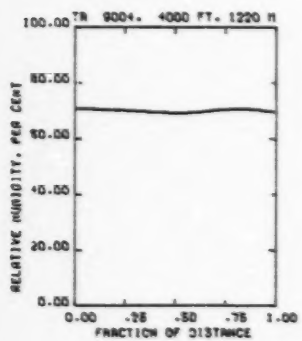
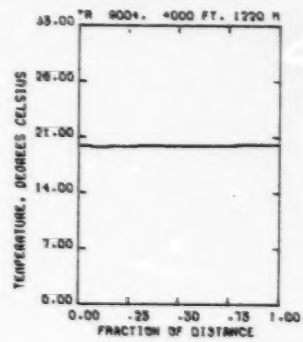
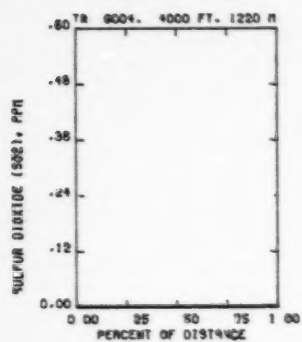
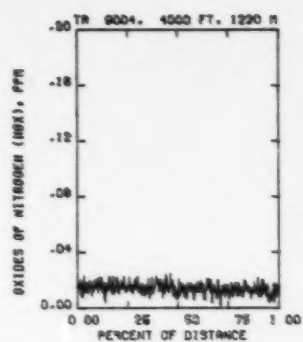
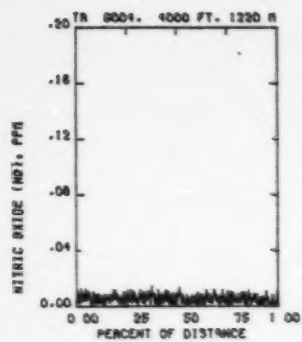




TR. 9004. 4000 FT. 1220 M. HOBBY TO DYERS INTERSECTION

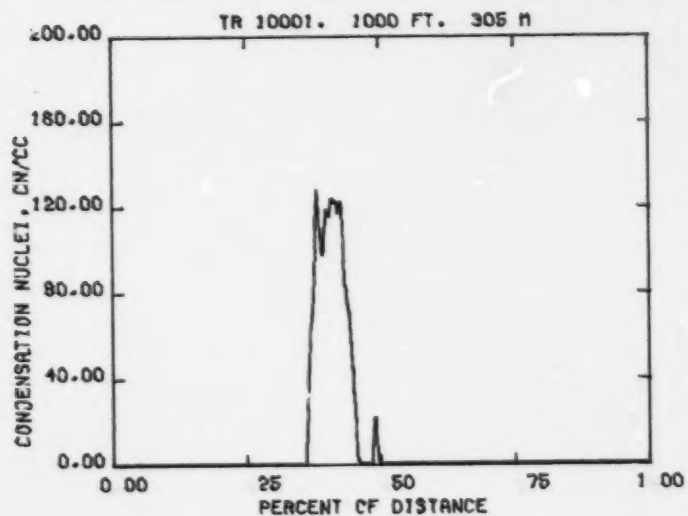
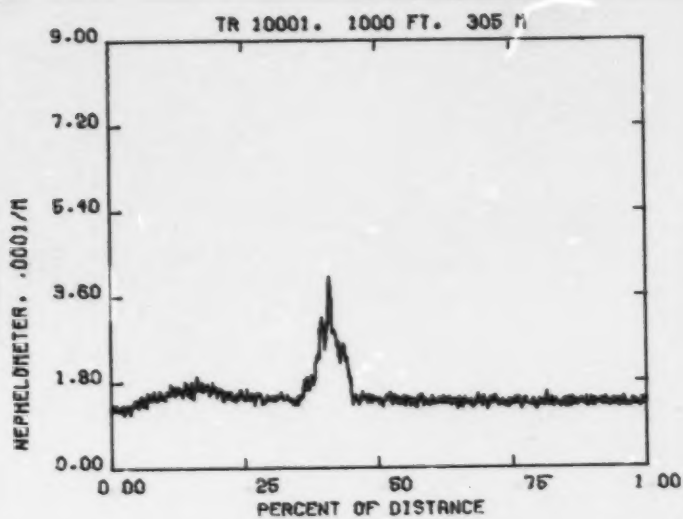
7/21/74. 7:03:50 TO 7:10:54. DISTANCE= 25.9 KM

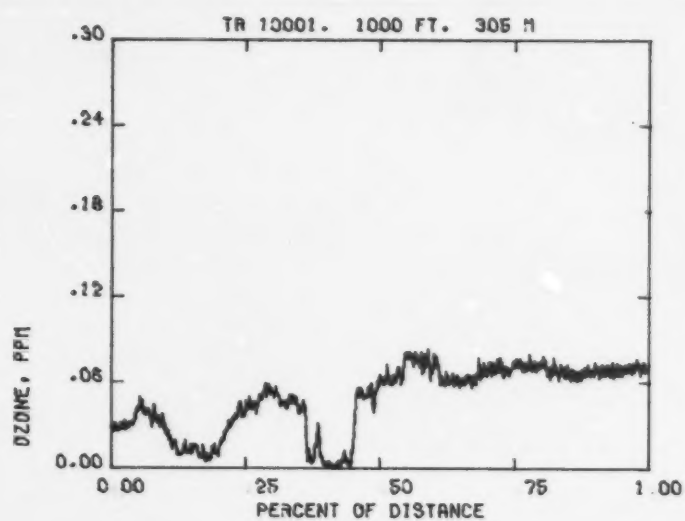
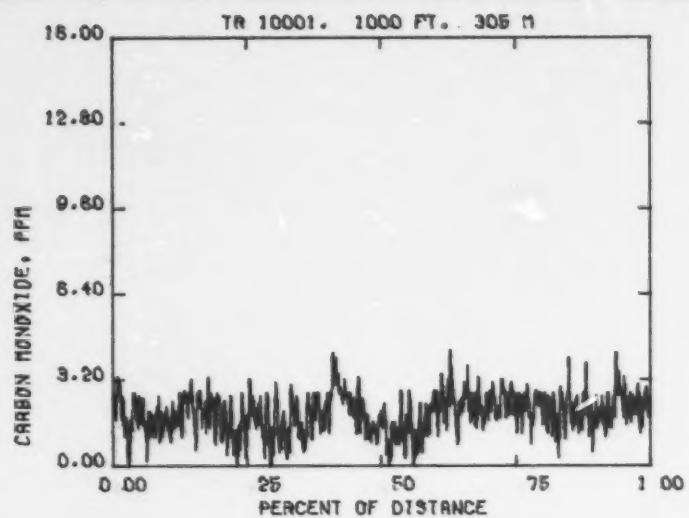


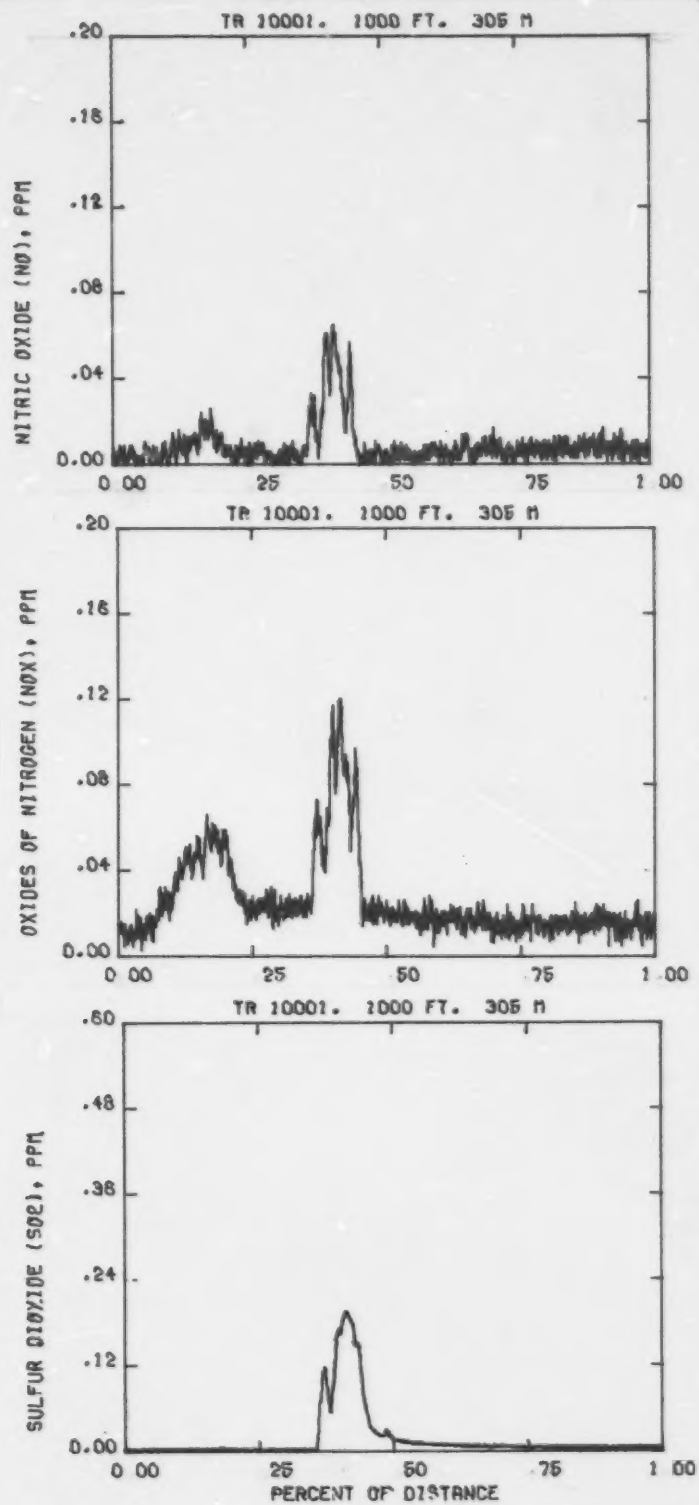


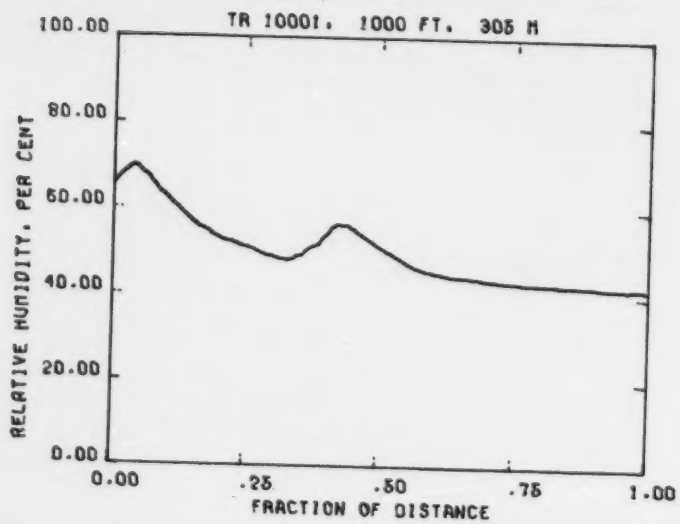
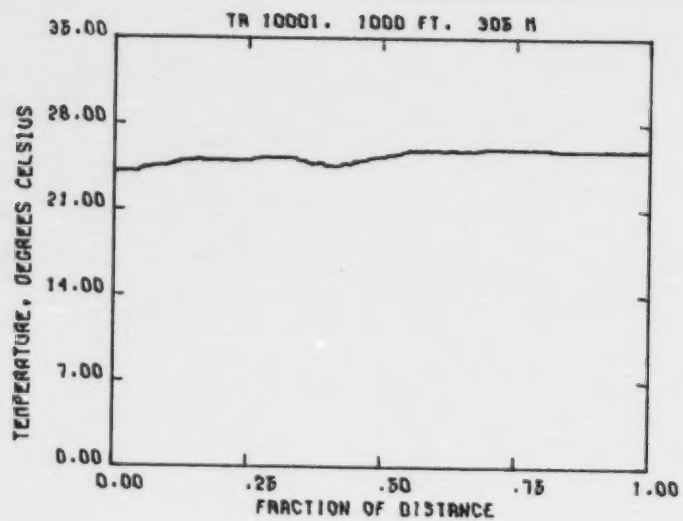
TR. 10001. 1000 FT. 305 M. CLEAR LAKE TO FLYING F

7/21/74. 7:36.3 TO 7:49.31. DISTANCE= 46.9 KM



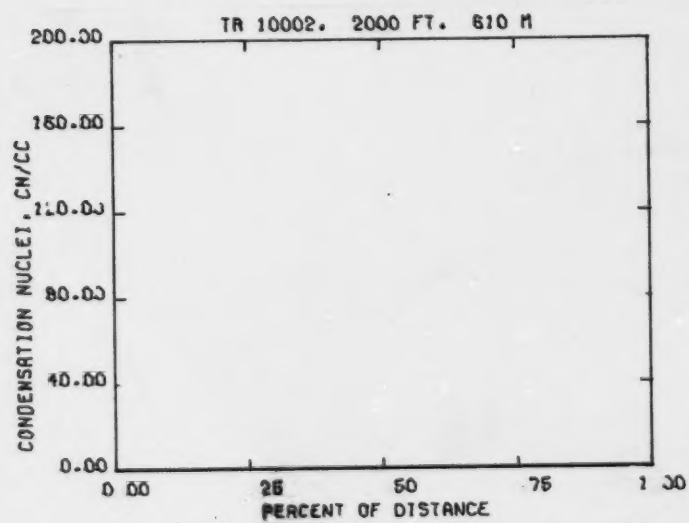
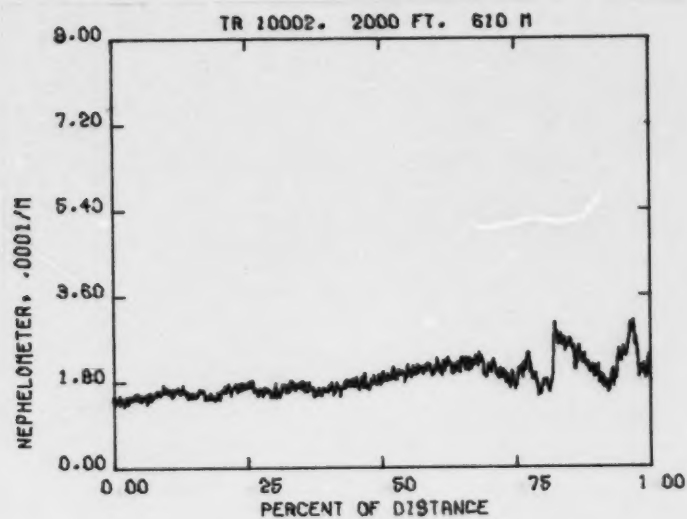


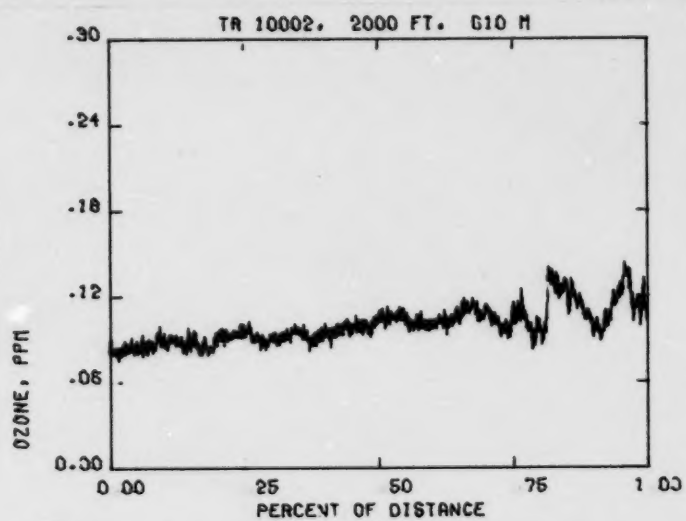
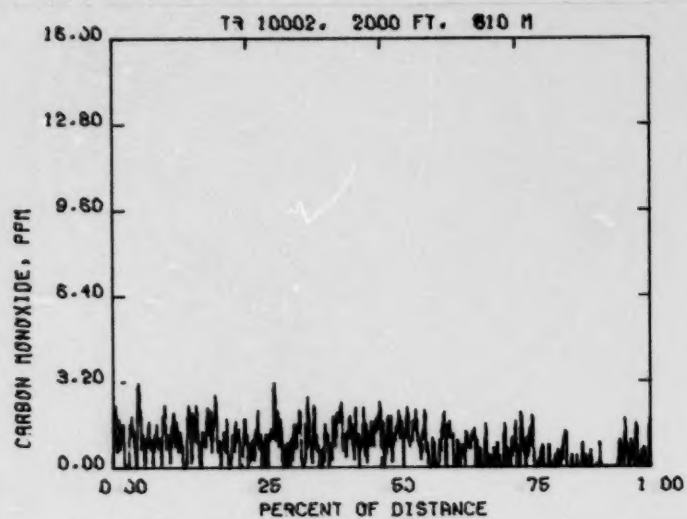


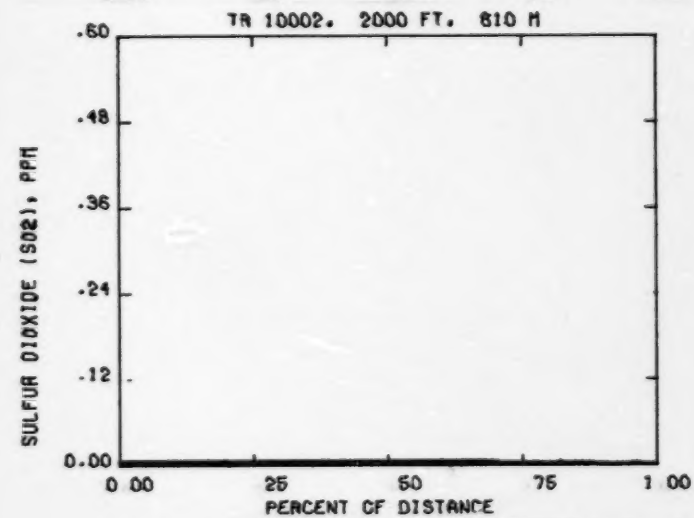
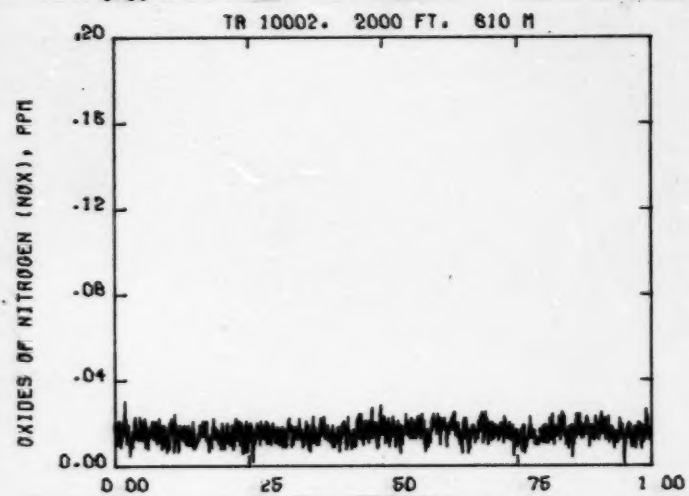
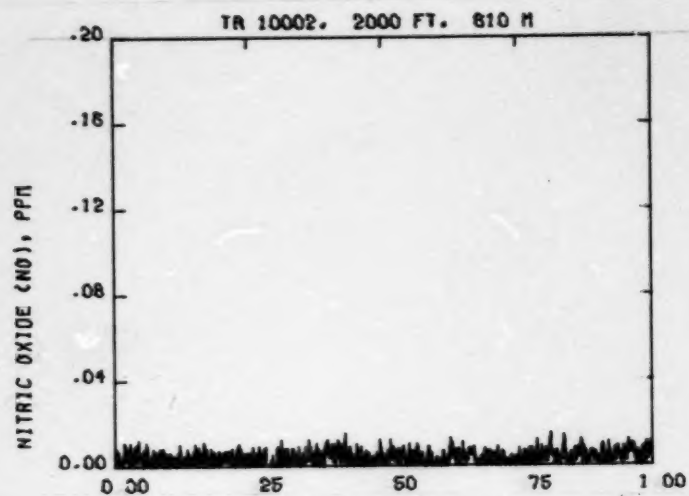


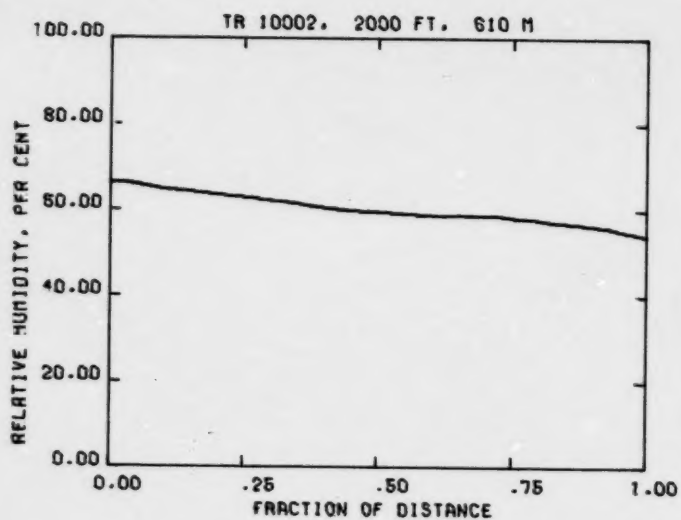
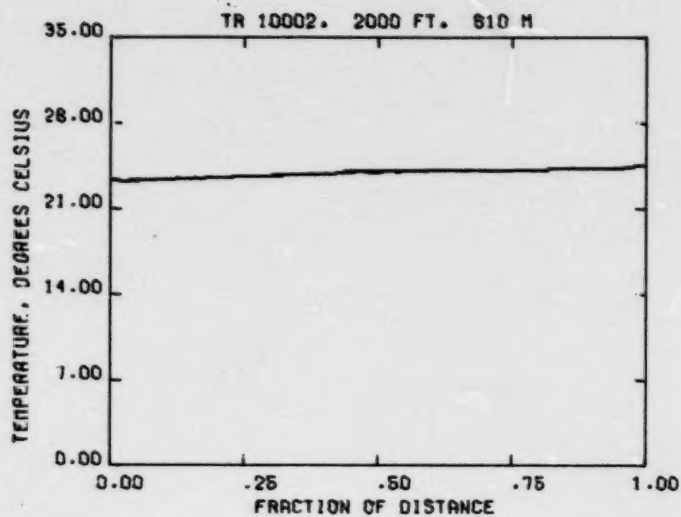
TR. 10002, 2000 FT, 610 M, CLEAR LAKE TO FLYING F

7/21/74. 7:52:21 TO 8:06:01. DISTANCE= 46.9 KM



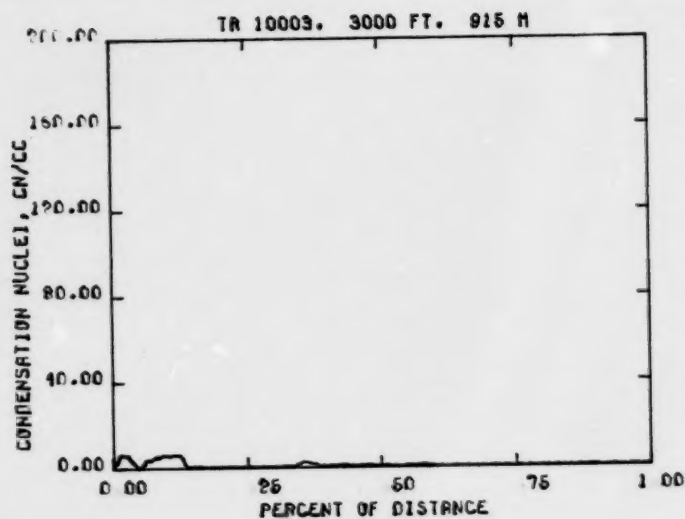
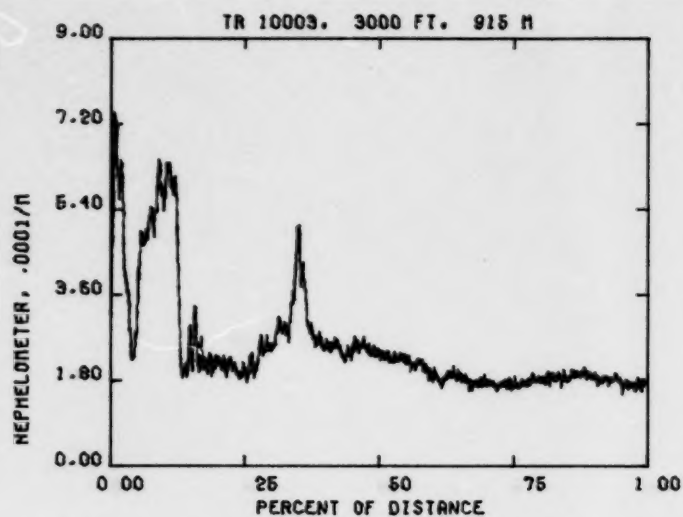


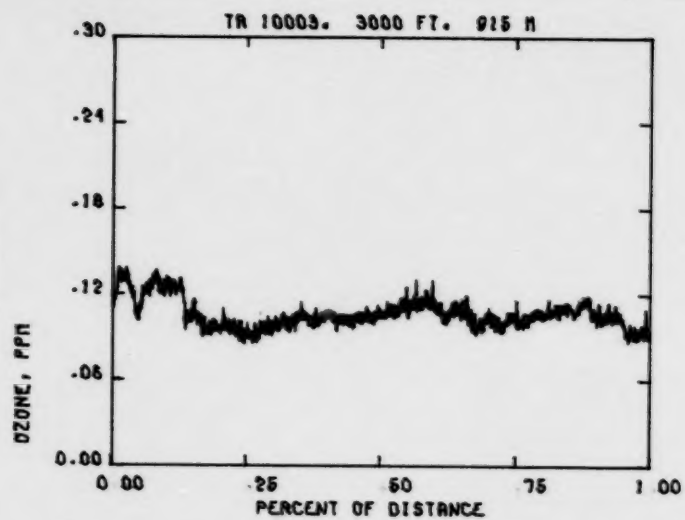
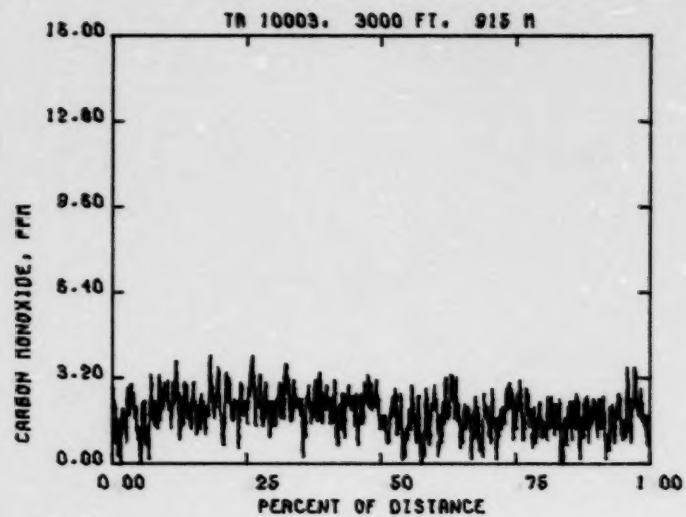


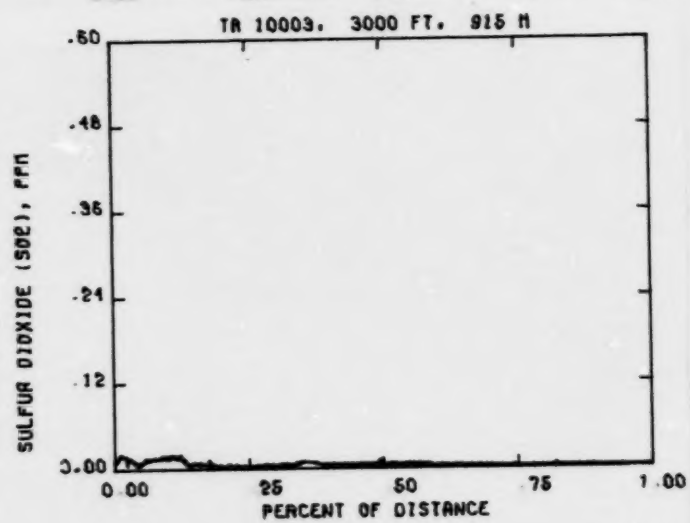
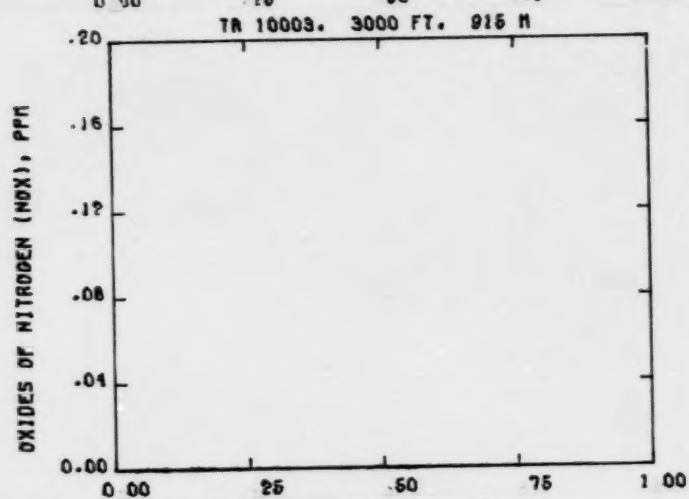
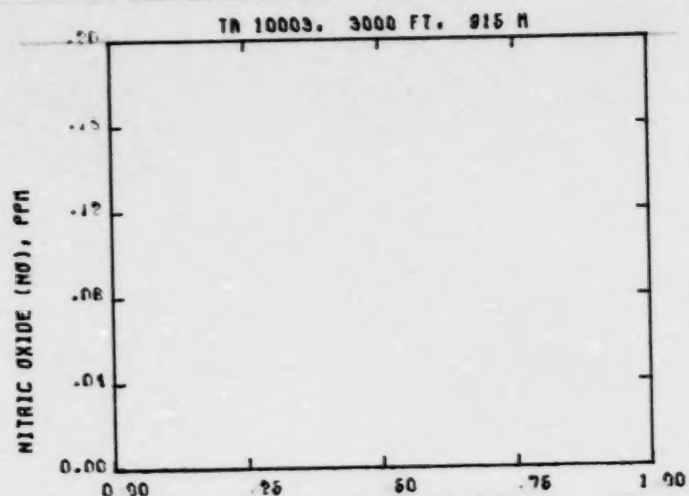


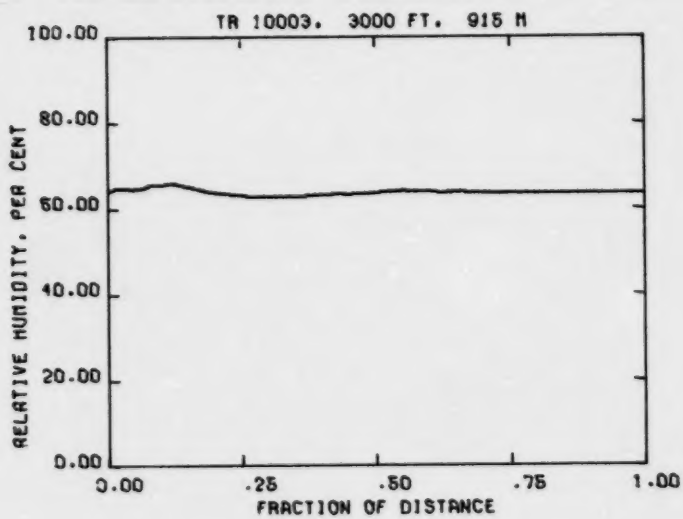
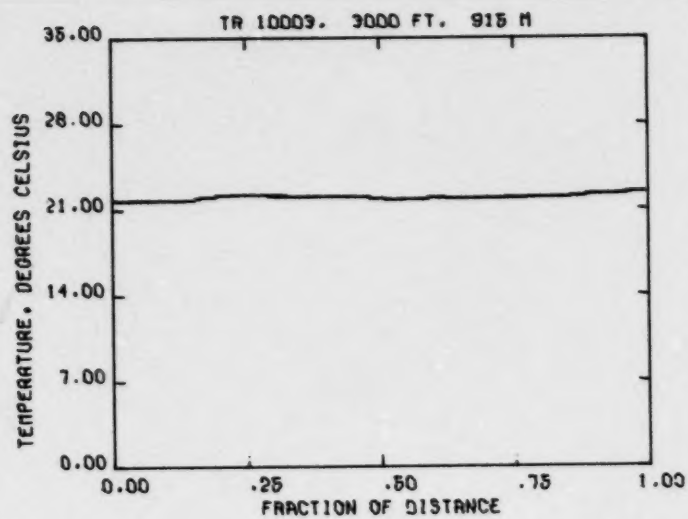
TR. 10003, 3000 FT. 915 M. CLEAR LAKE TO FLYING F

7/21/74. 8:19.38 TO 8:23.16. DISTANCE= 46.9 KM



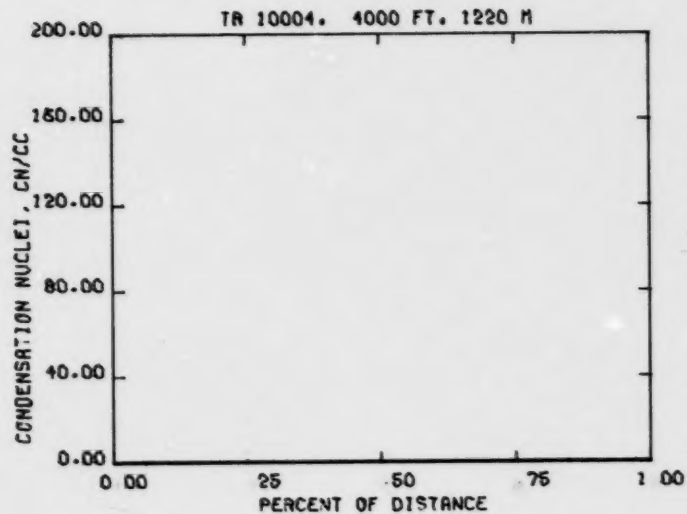
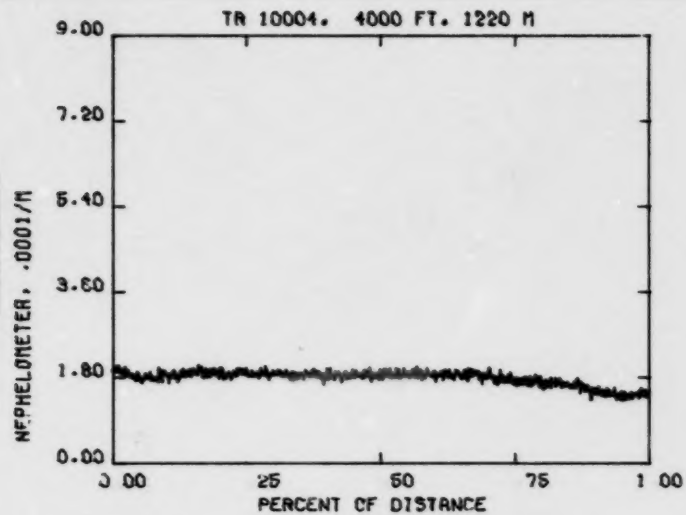


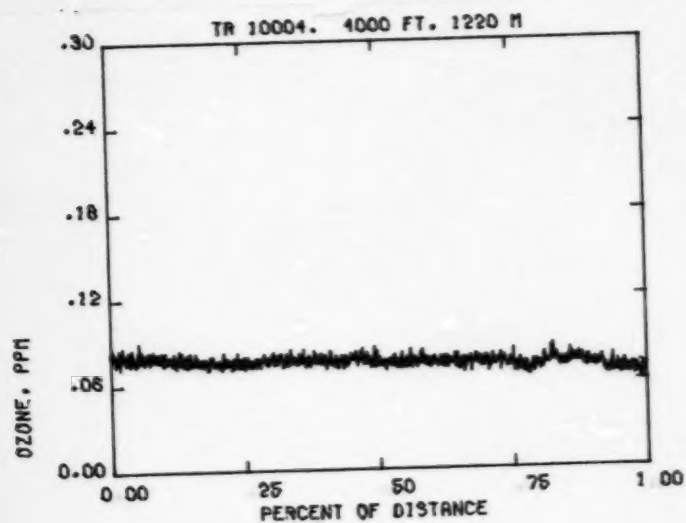
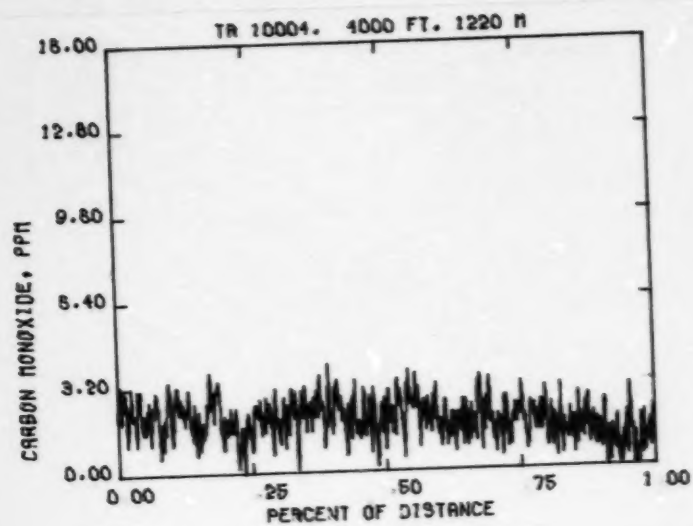


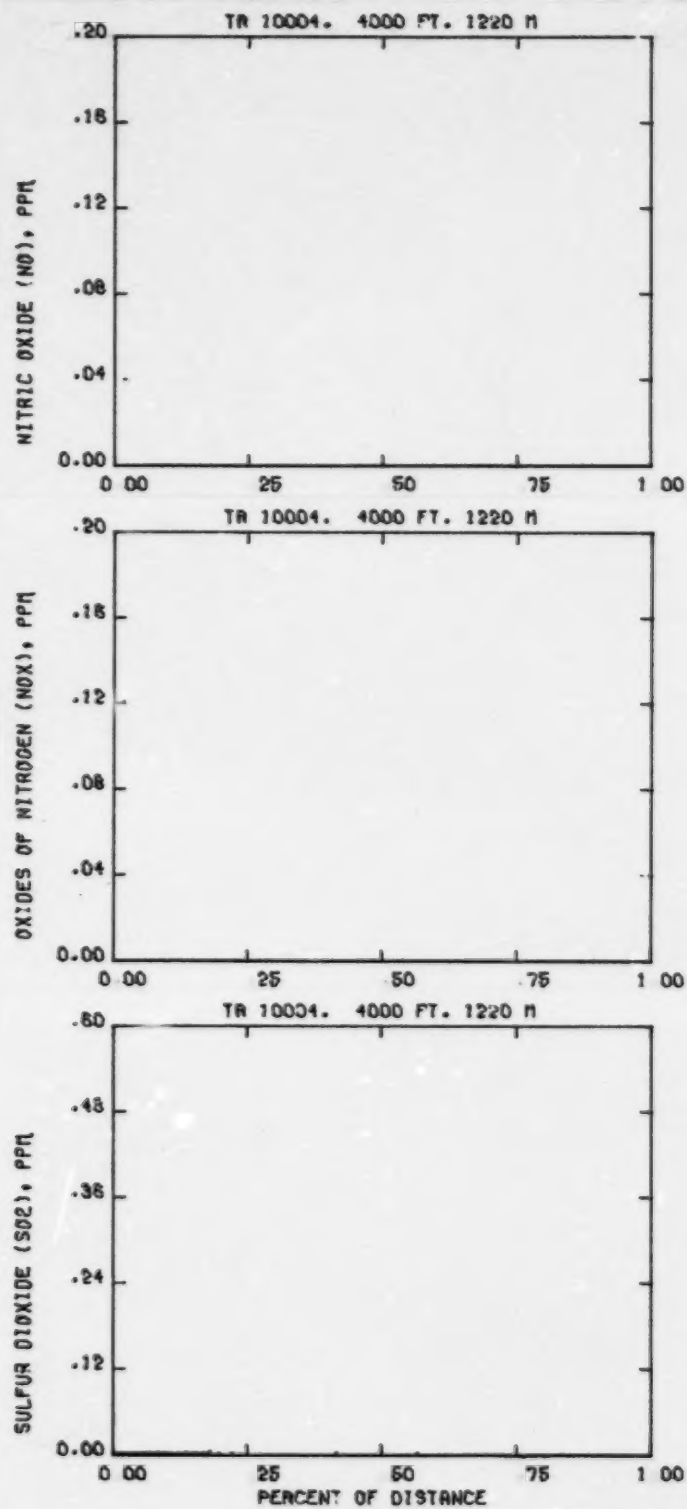


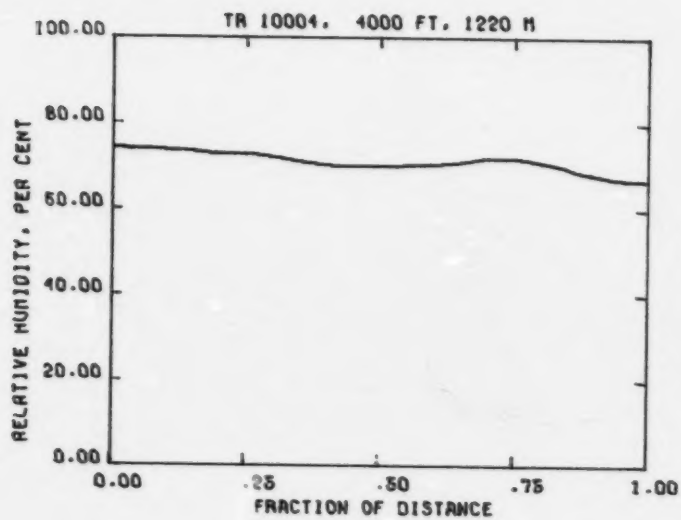
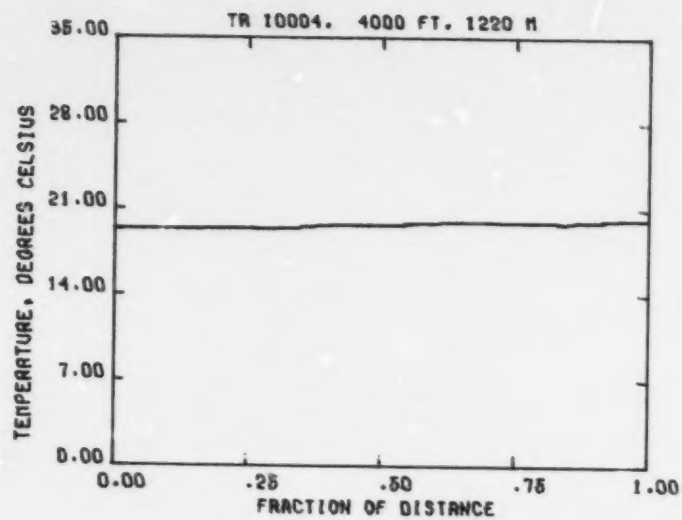
TR 10004. 4000 FT. 1220 M. CLEAR LAKE TO FLYING F

7/21/74. 8:26:53 TO 8:39:42. DISTANCE= 46.9 KM



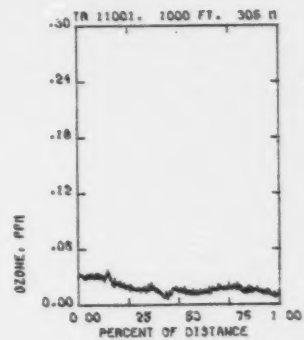
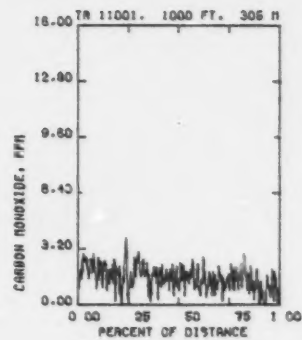
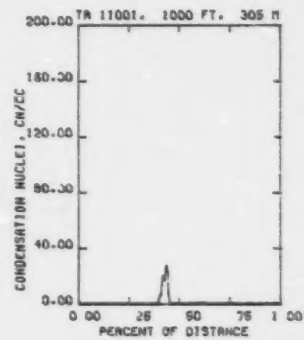
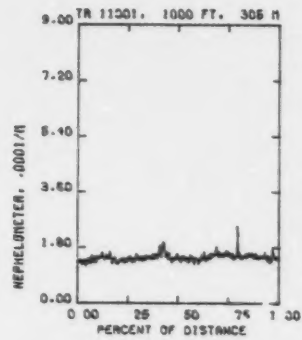


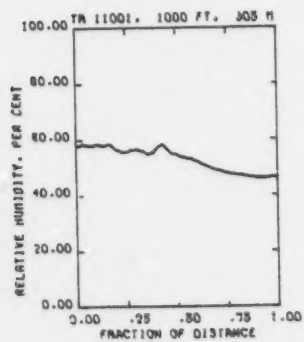
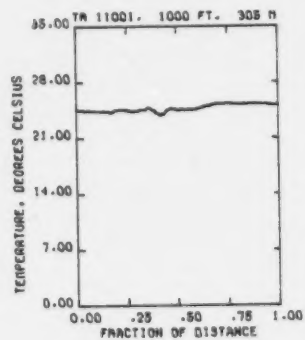
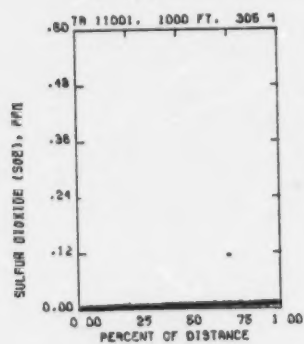
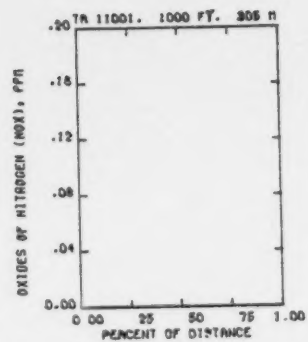
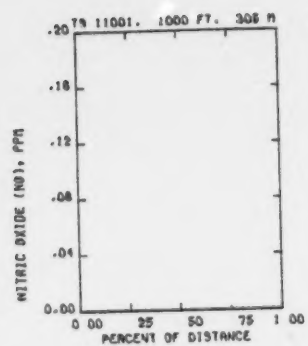




TR. 11001. 1000 FT. 306 M. HOBBY TO DYERS INTERSECTION

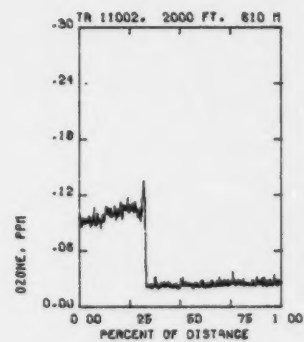
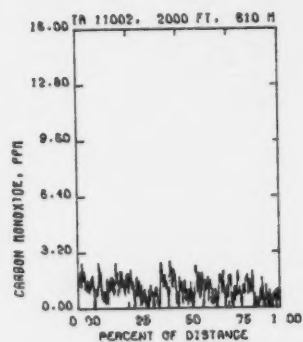
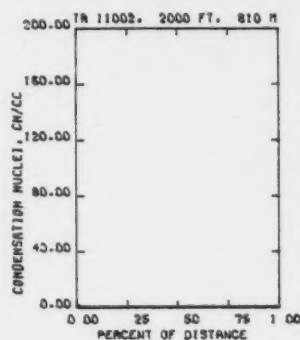
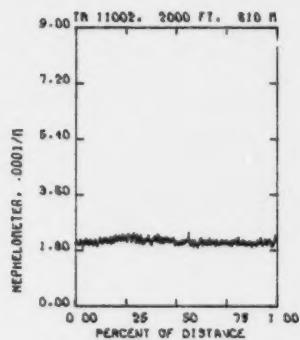
7/22/74. 7:26:39 TO 7:33:35. DISTANCE= 26.9 KM

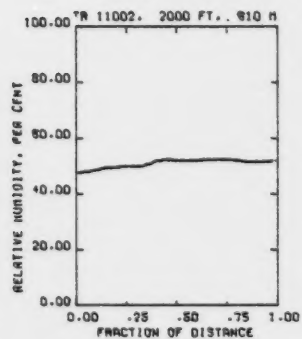
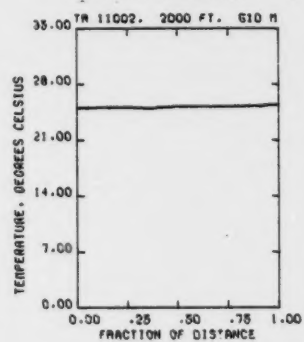
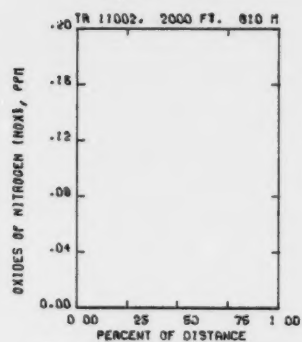
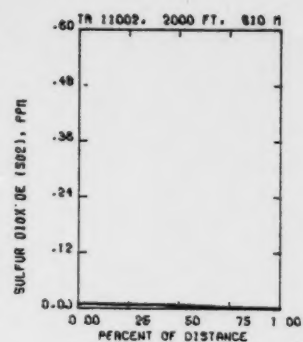
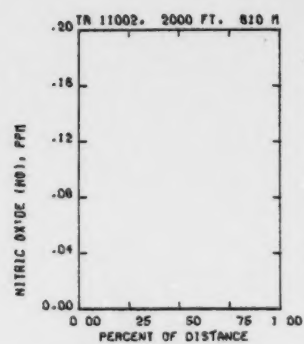




TR. 11002, 2000 FT, 610 M, HOBBY TO DYERS INTERSECTION

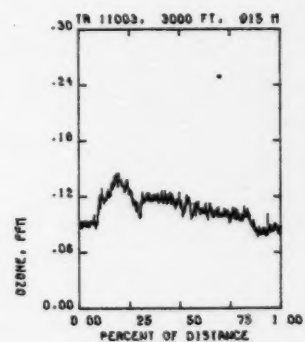
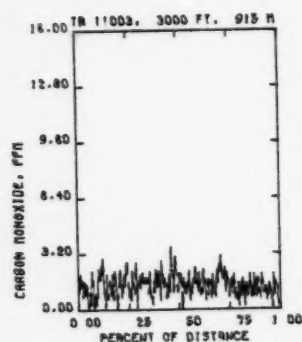
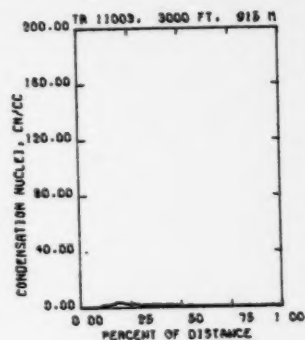
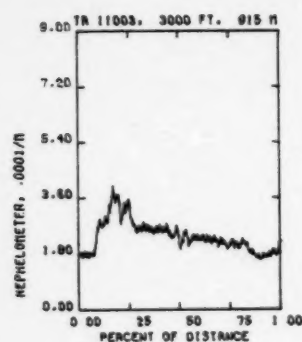
7/22/74, 7:36:51 TO 7:44:14, DISTANCE= 26.9 KM

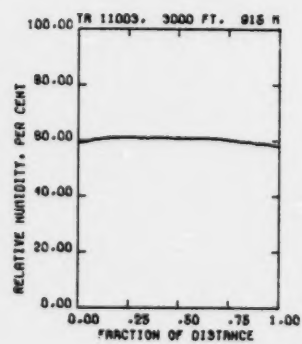
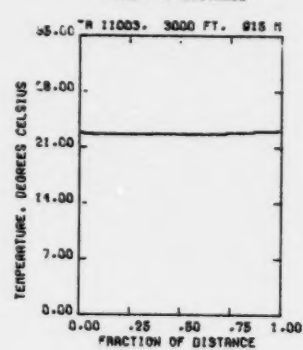
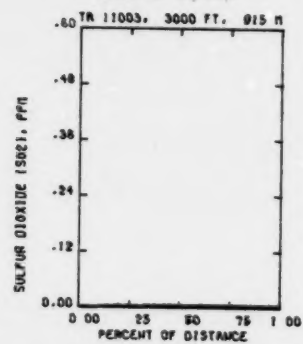
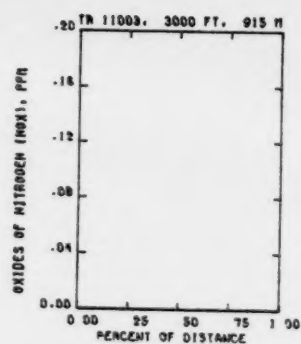
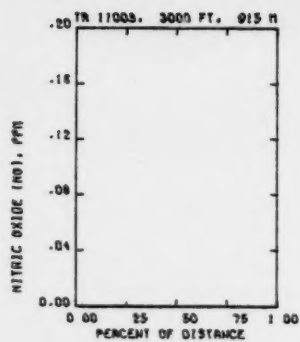




TR. 11003, 3000 FT. 915 M. HOBBY TO DYERS INTERSECTION

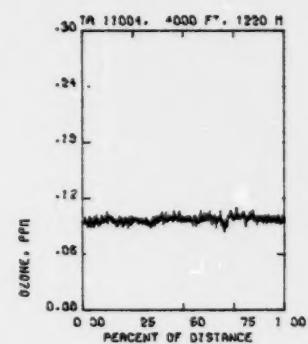
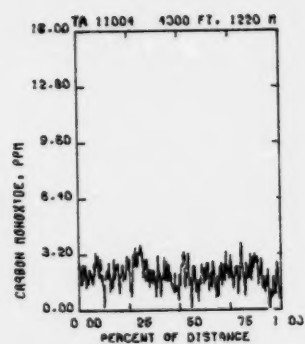
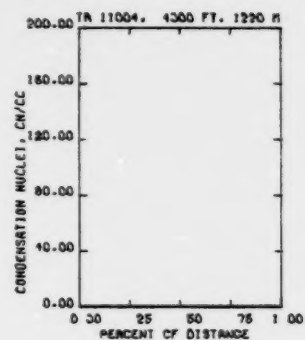
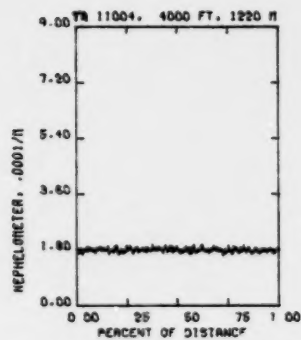
7/22/74, 7:47:27 TO 7:54:51, DISTANCE= 26.9 KM

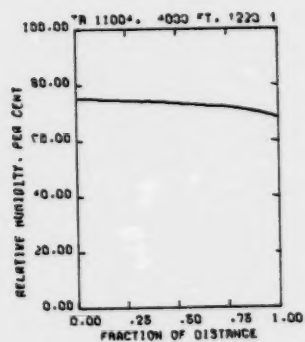
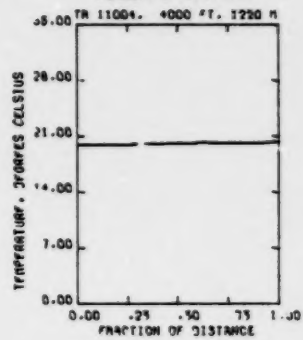
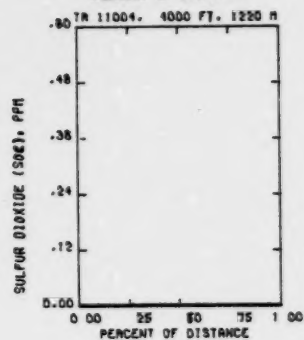
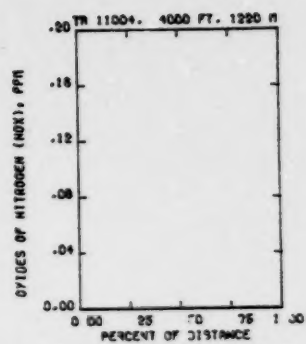
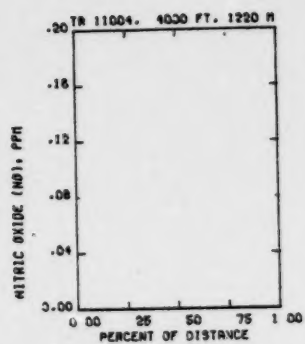




TR. 11004. 4000 FT. 1220 M. HOBBY TO DYERS INTERSECTION

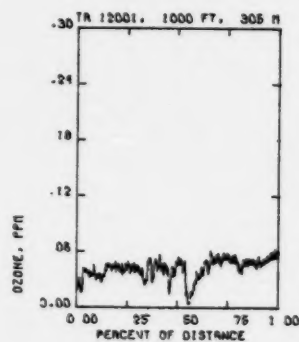
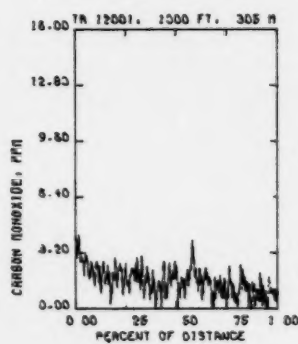
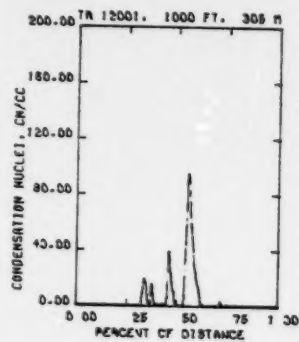
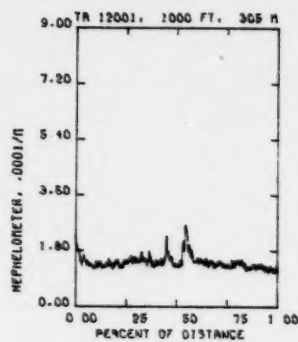
7/22/74. 7:58:37 TO 8:05:14. DISTANCE= 26.9 KM

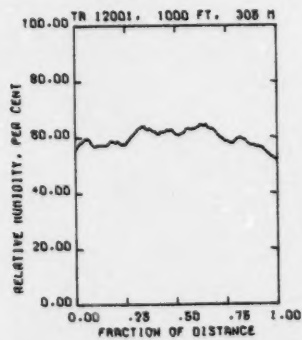
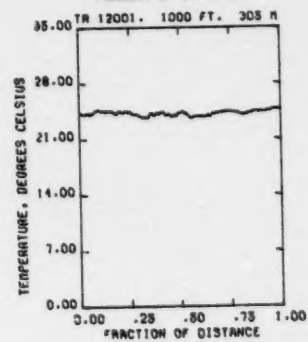
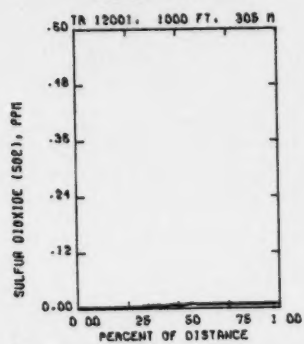
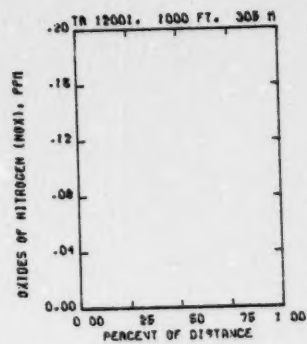
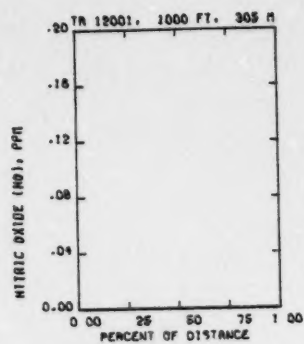




TA 12001, 1000 FT, 305 M, HOBBY TO DYERS INTERSECTION

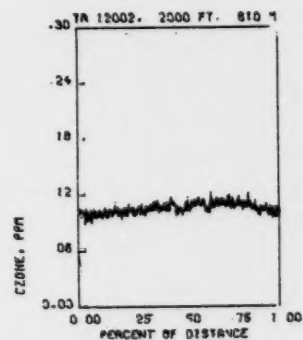
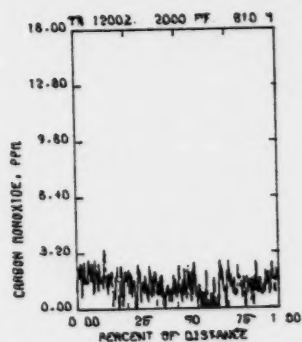
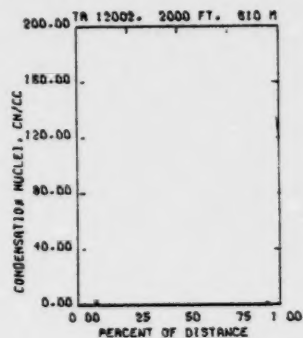
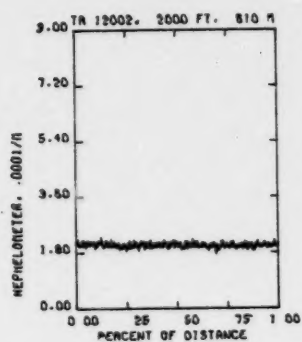
7/22/74, 8:10:30 TO 8:17:55, DISTANCE= 26.9 KM

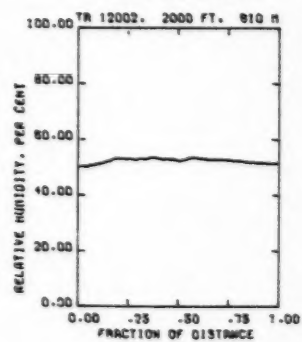
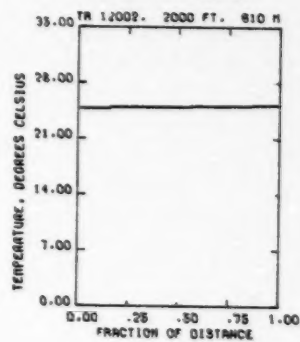
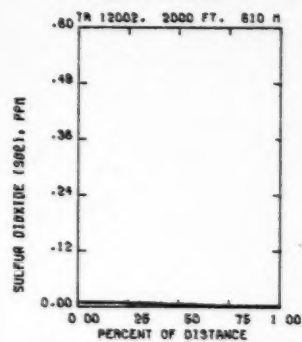
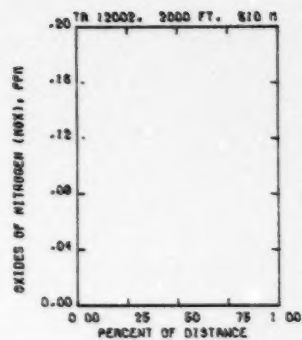
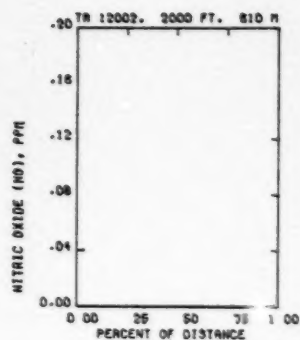




TR. 12002. 2000 FT. 810 M. HOBBY TO DYERS INTERSECTION

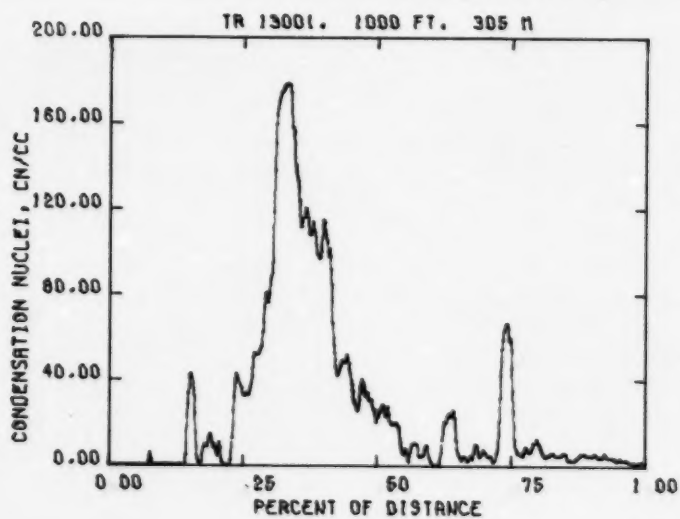
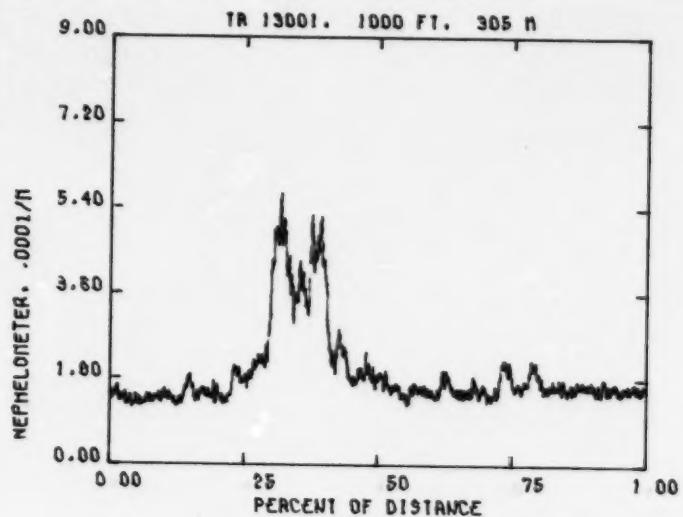
7/22/74. 8:21:18 TO 8:28:52. DISTANCE= 26.9 KM

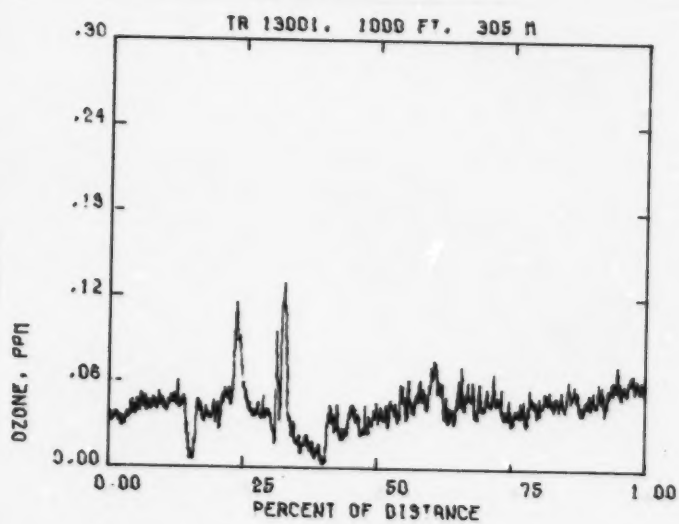
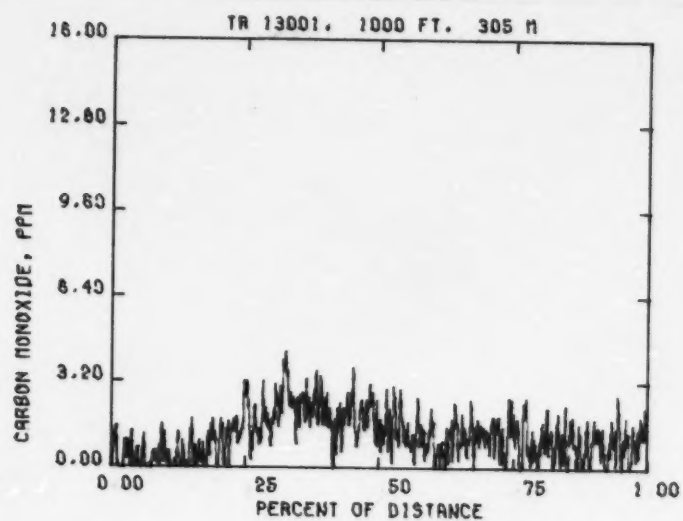


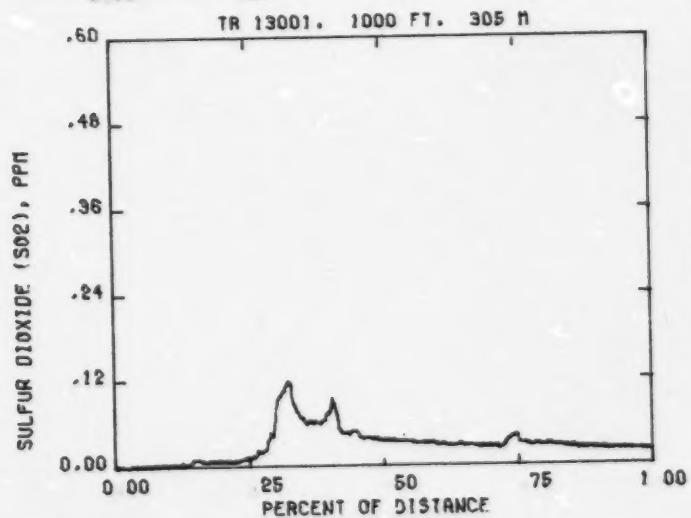
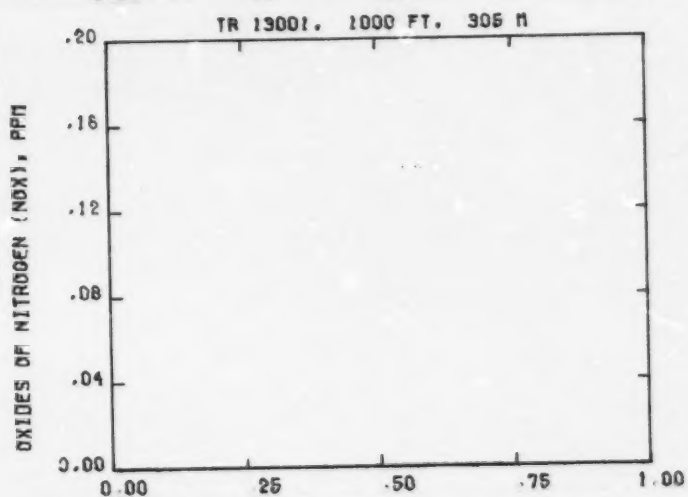
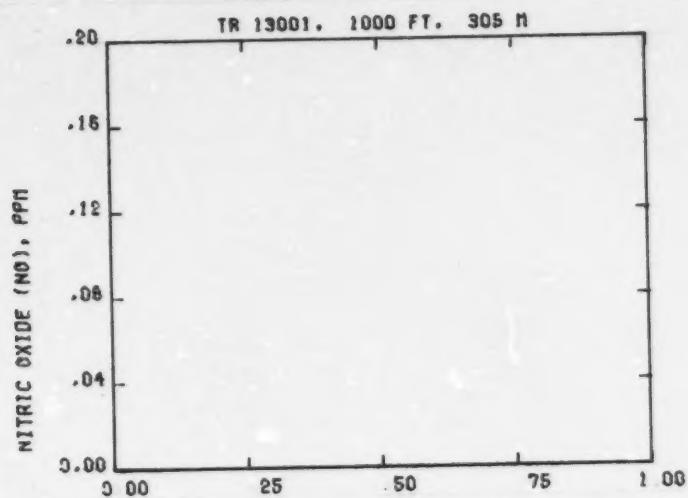


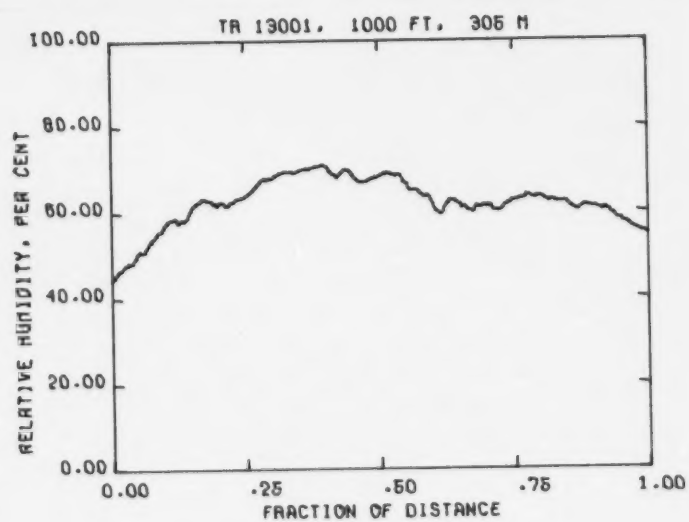
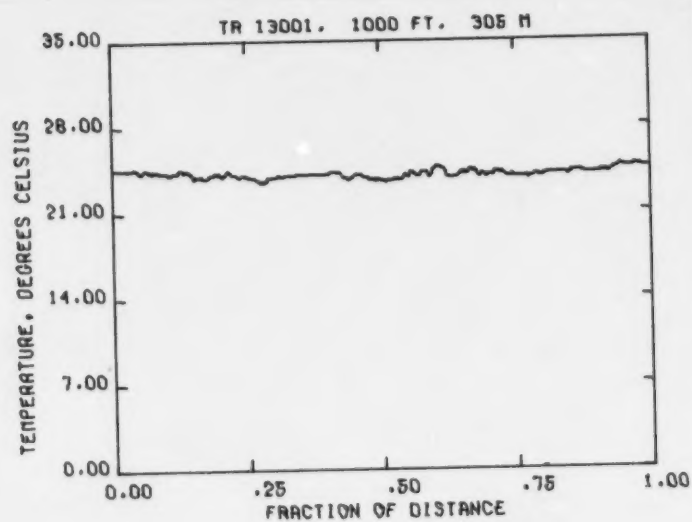
TR. 13001. 1000 FT. 305 M. CLEAR LAKE TO FLYING F

7/22/74. 8:56:15 TO 9:10:14. DISTANCE= 46.9 KM



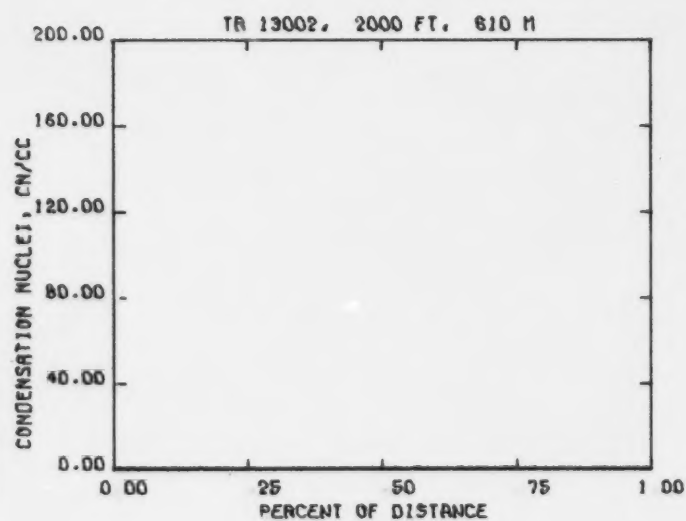
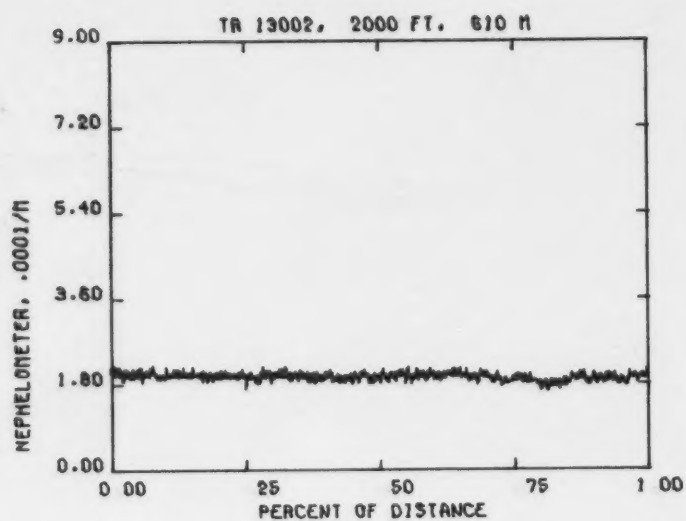


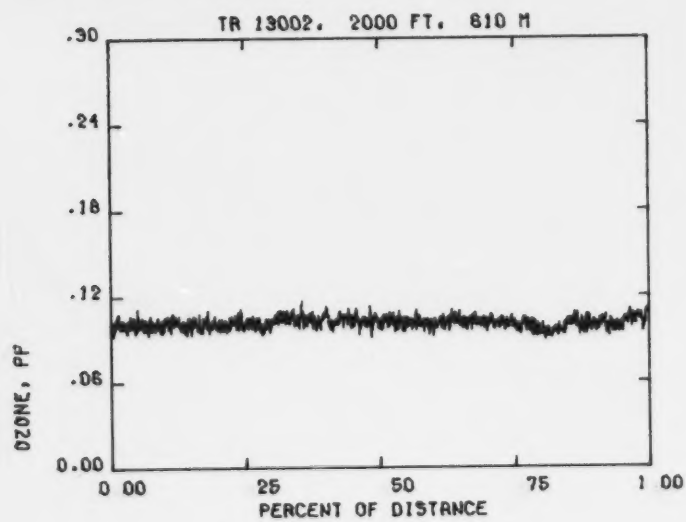
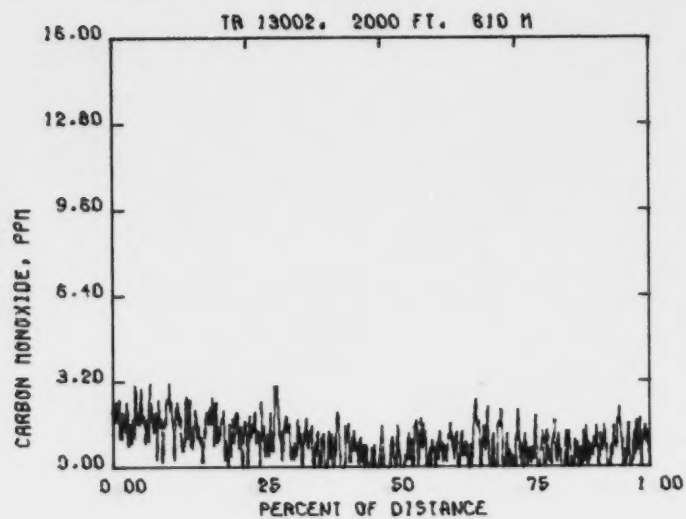


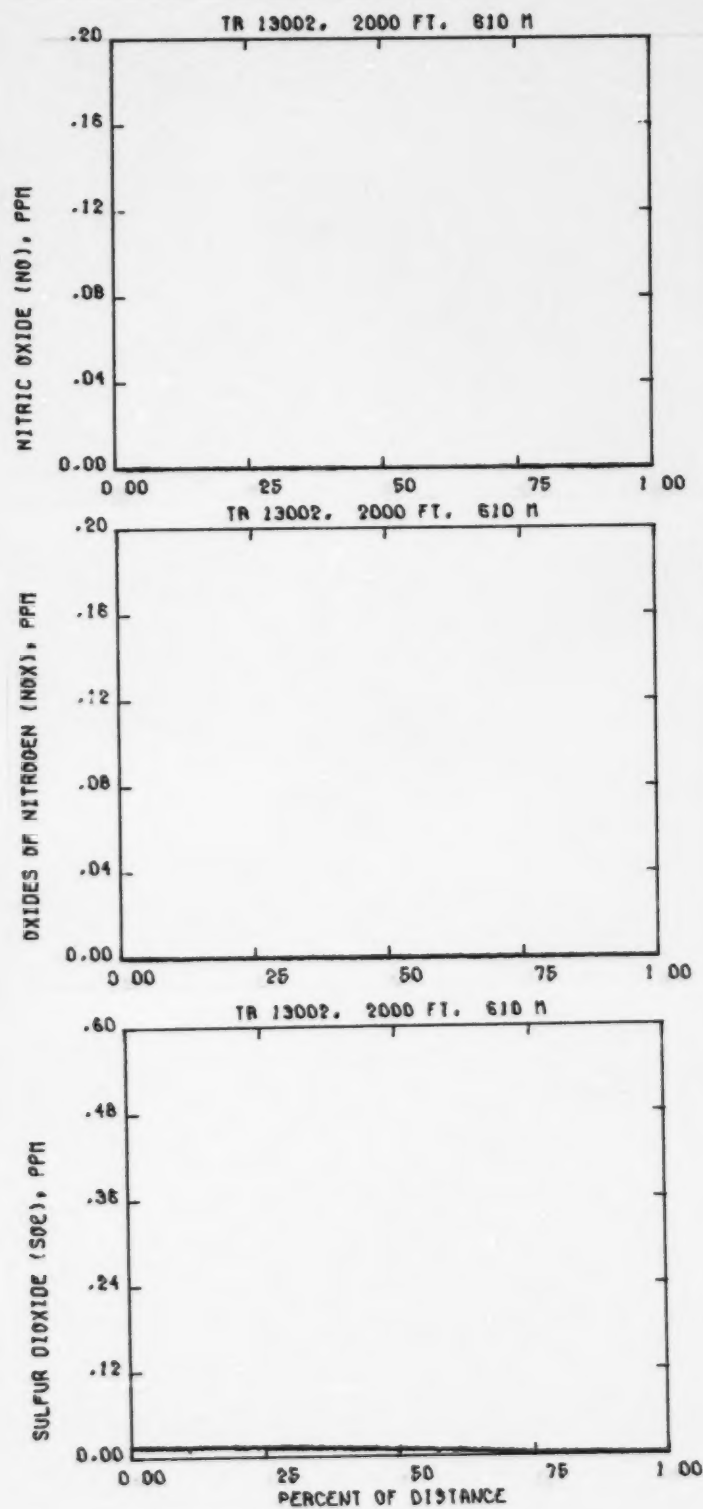


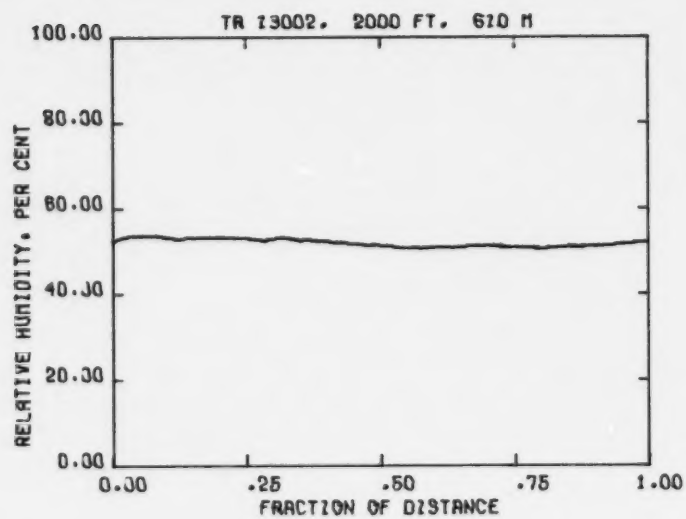
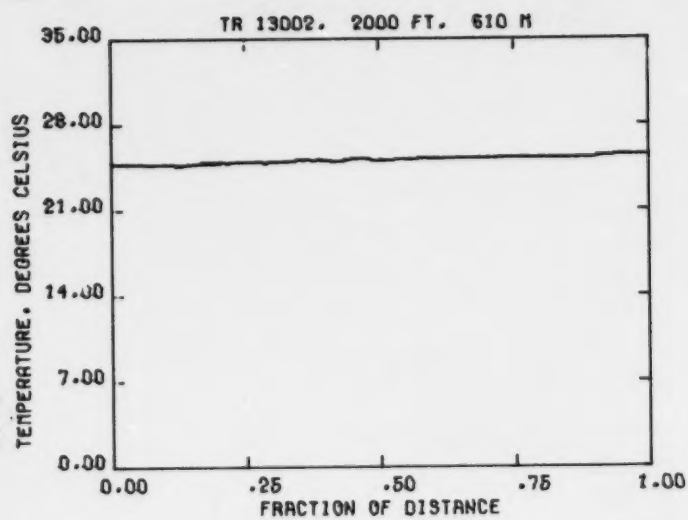
TR. 13002, 2000 FT, 610 M, CLEAR LAKE TO FLYING F

7/22/74, 9:13:0 TO 9:25:55, DISTANCE= 46.9 KM



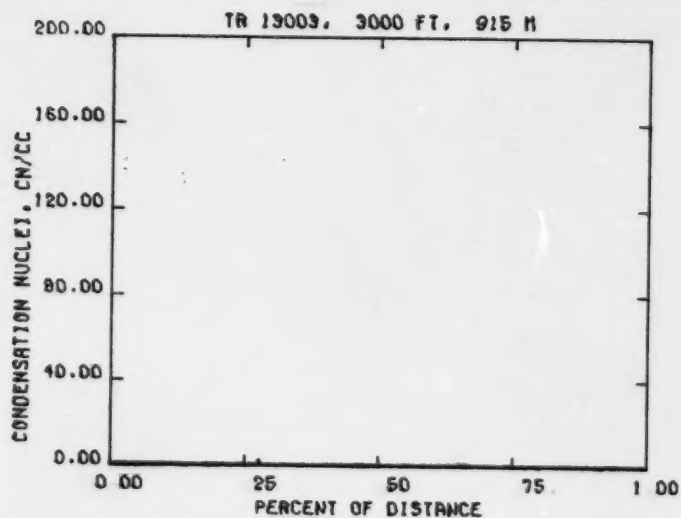
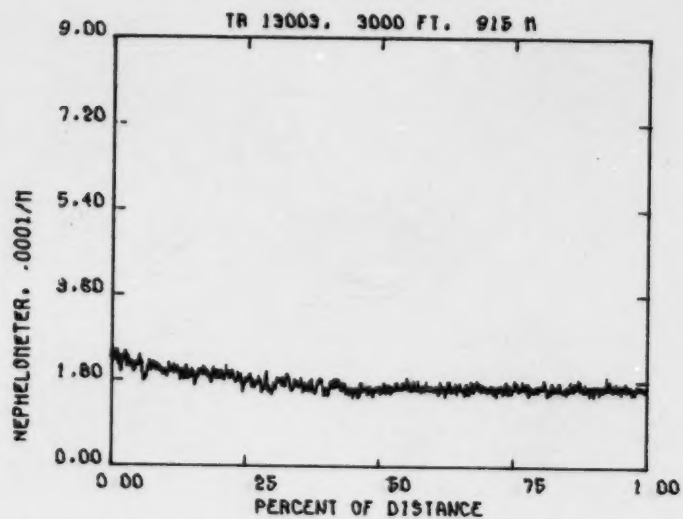


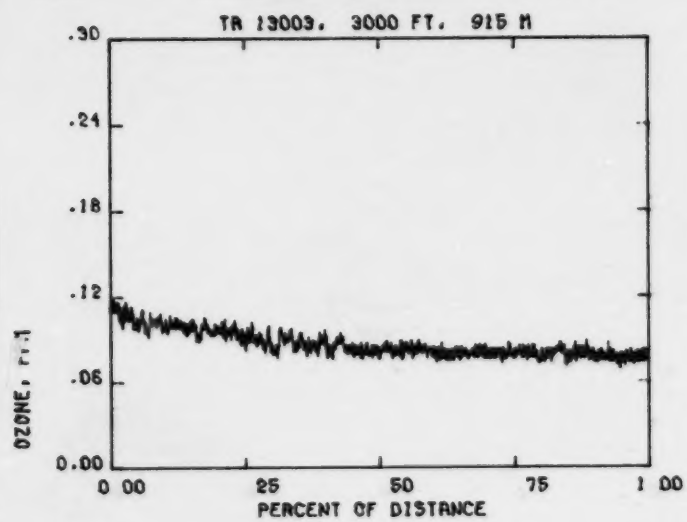
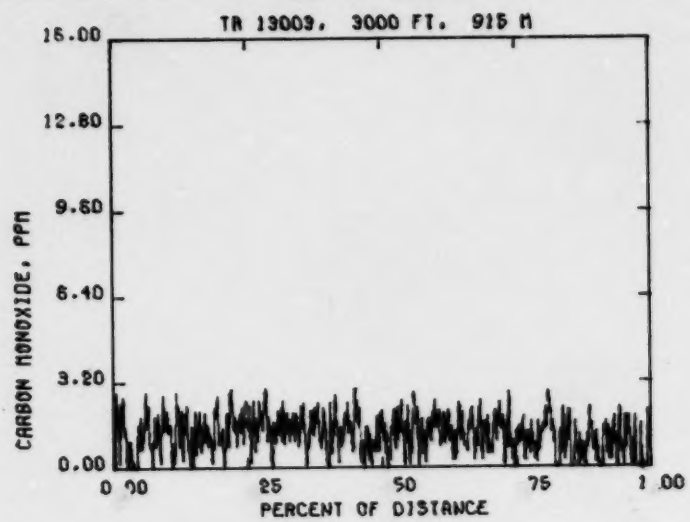


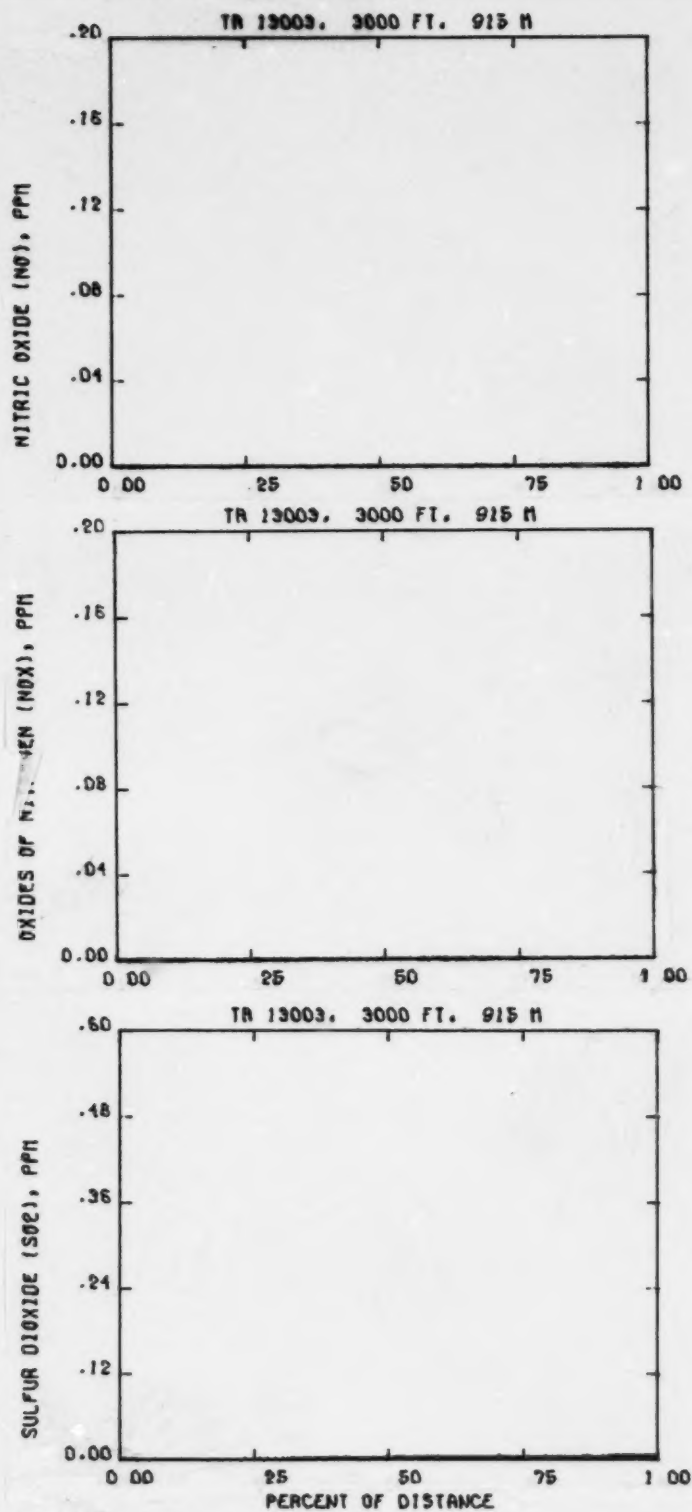


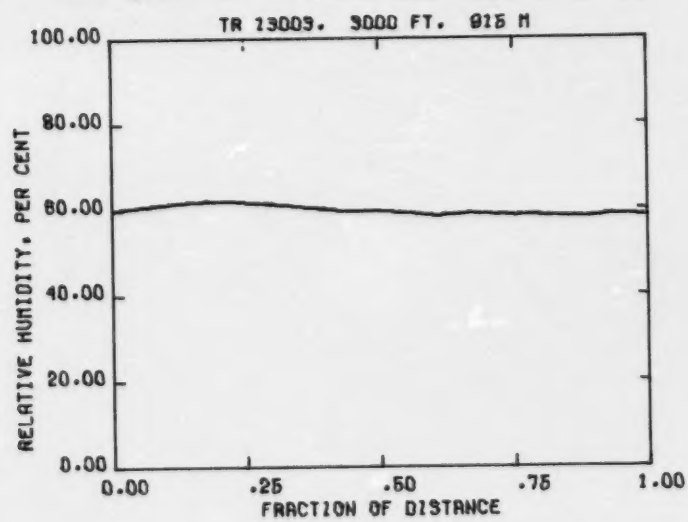
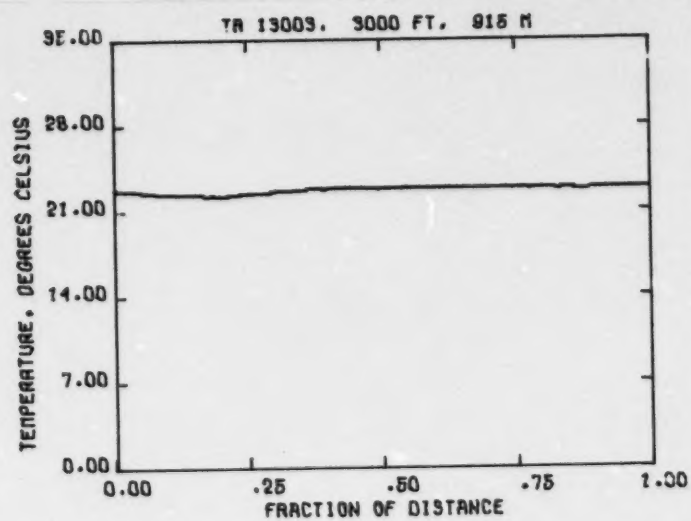
TR. 13003, 3000 FT, 915 M, CLEAR LAKE TO FLYING F

7/22/74, 9.29.1 TO 9.43.44, DISTANCE= 46.9 KM



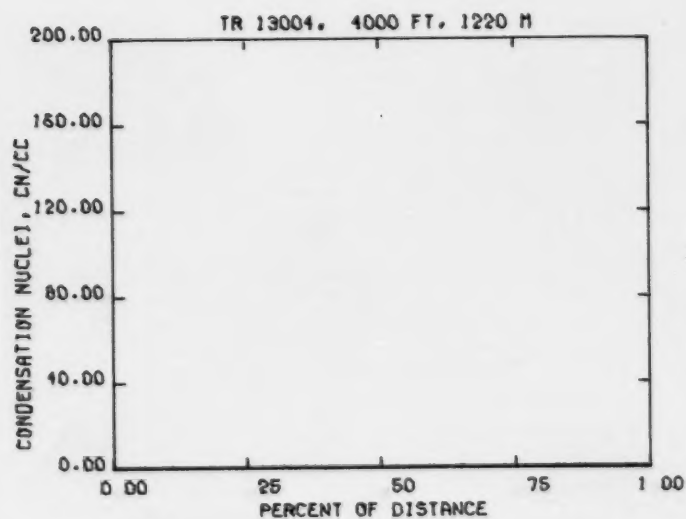
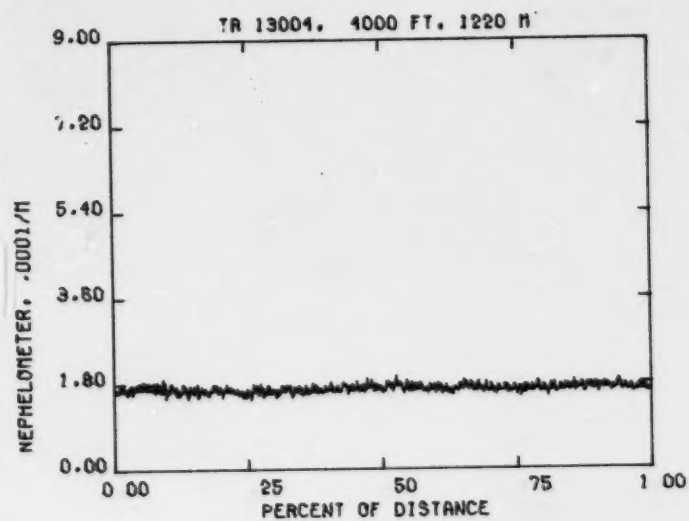


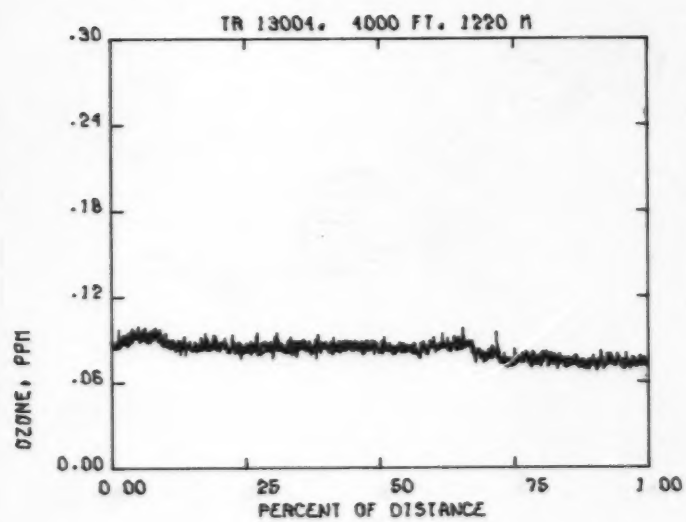
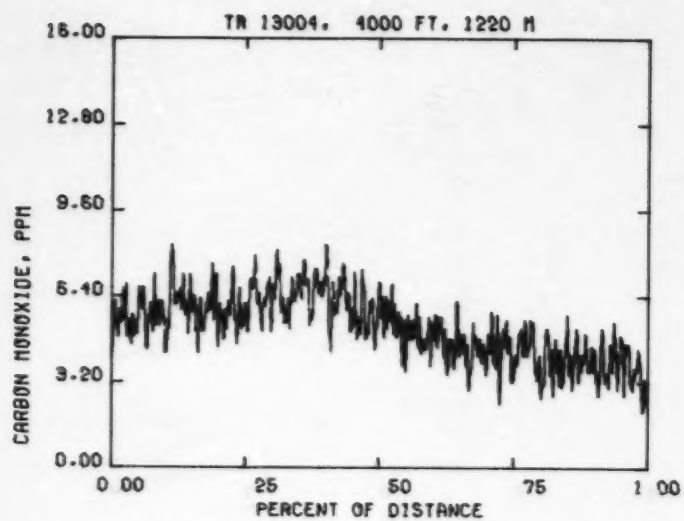


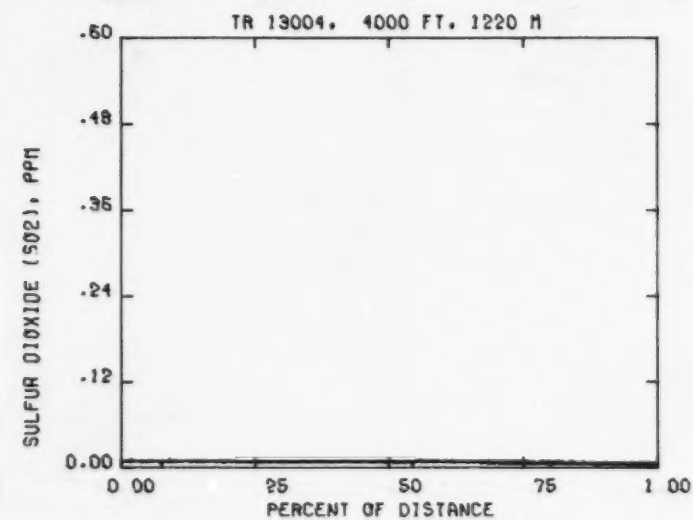
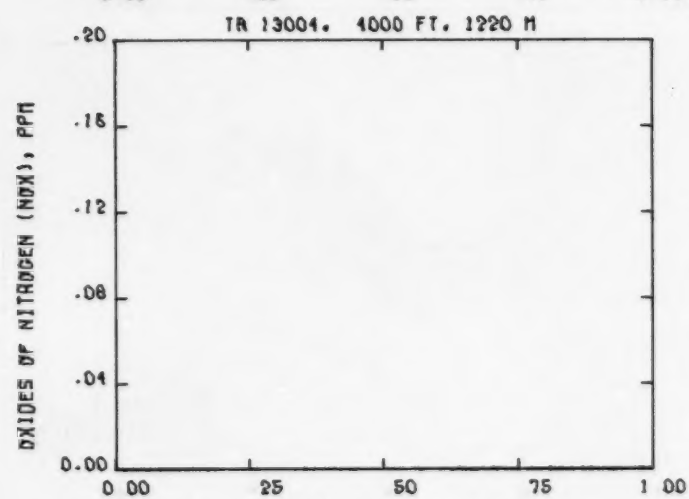
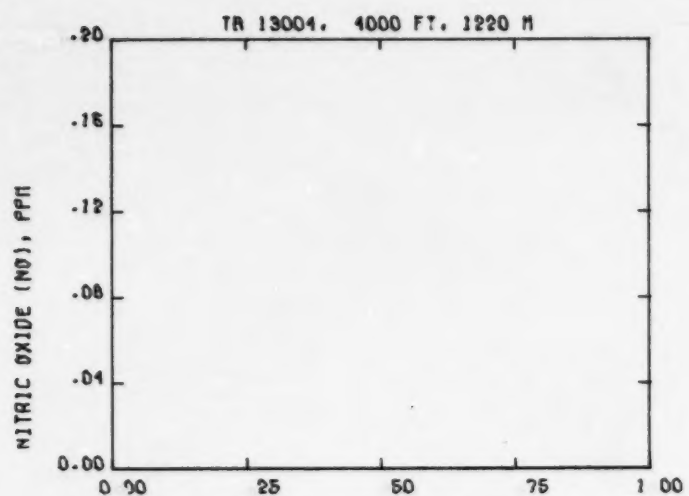


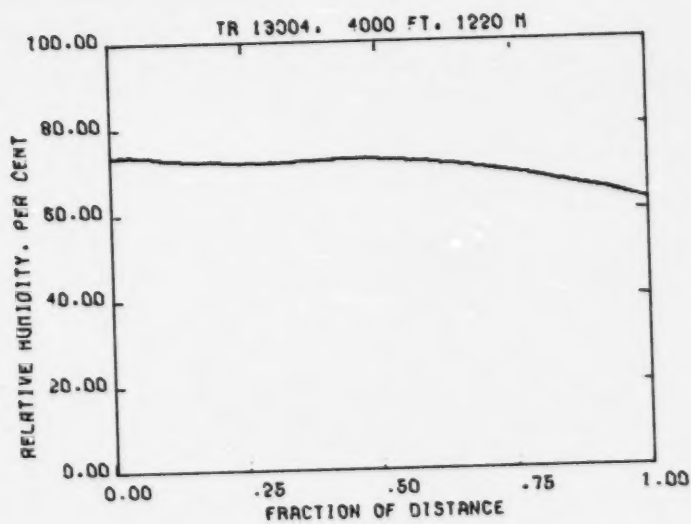
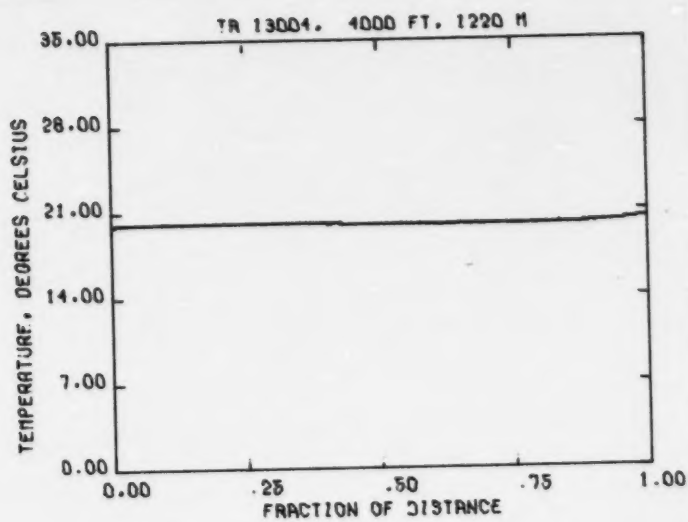
TR. 13004. 4000 FT. 1220 M. CLEAR LAKE TO FLYING F

7/22/74, 9.46.33 TO 9.58.17, DISTANCE= 46.9 KM



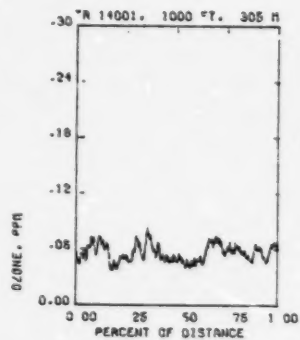
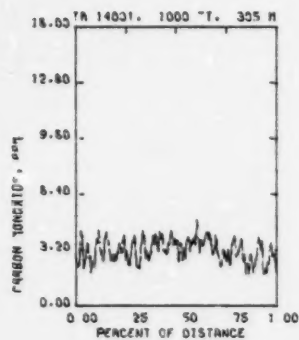
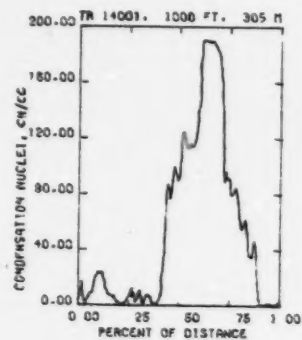
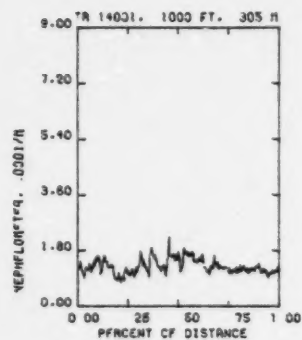


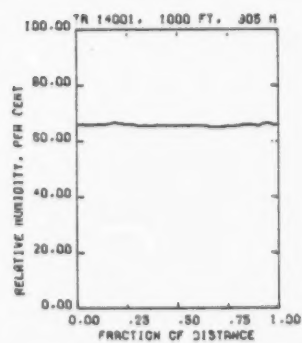
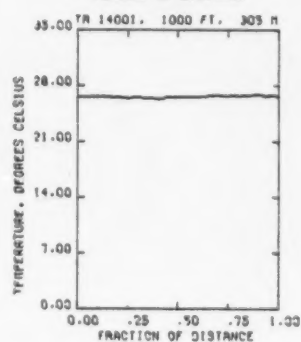
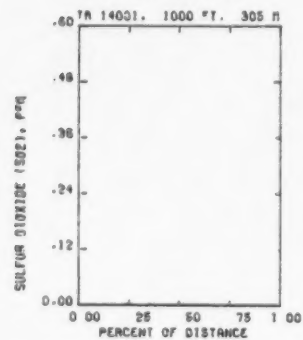
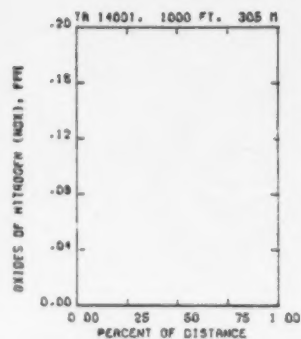
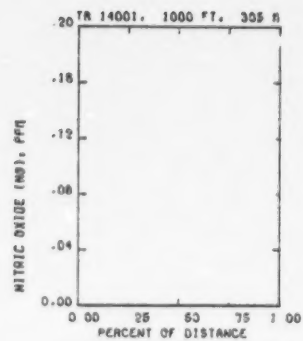




TR. 14001. 1000 FT. 305 M. POINTS -II- TO -I-

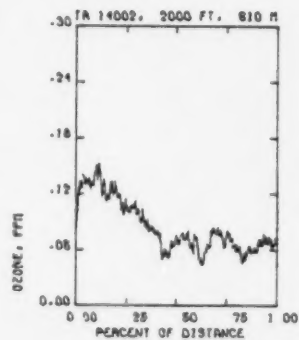
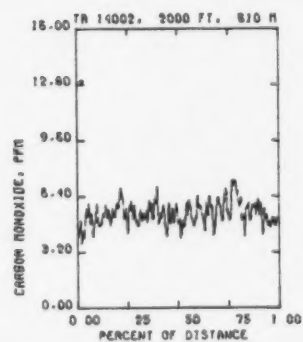
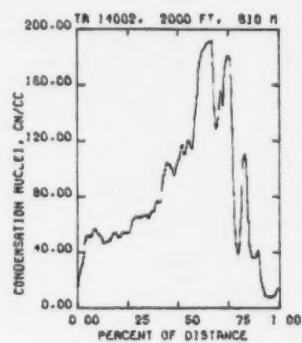
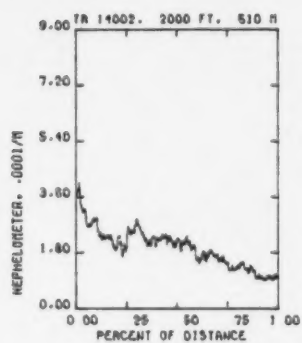
7/24/74. 16.28.31 TO 16.32.51. DISTANCE= 12.0 KM

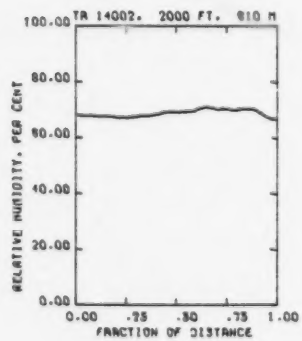
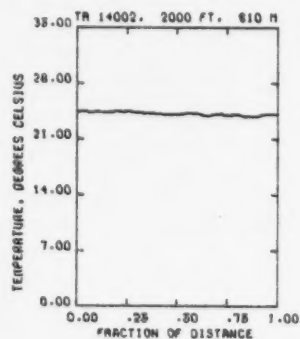
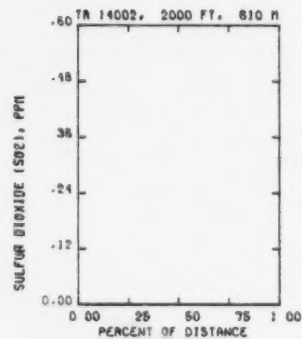
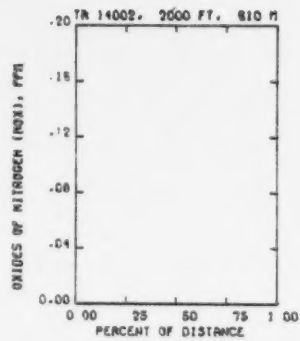
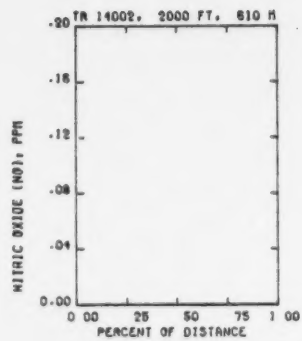




TR. 14002, 2000 FT, 810 M, POINTS -II- TO -I-

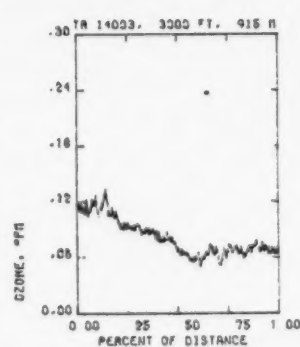
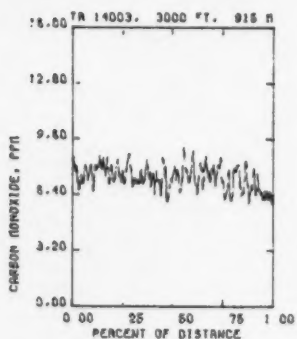
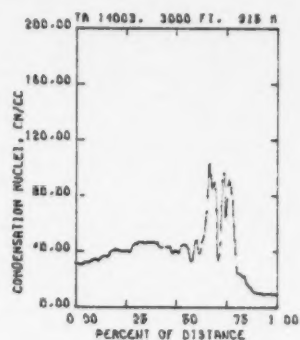
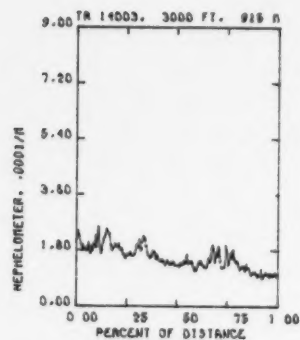
7/24/74, 16:35.6 TO 16:39.41, DISTANCE= 12.0 KM

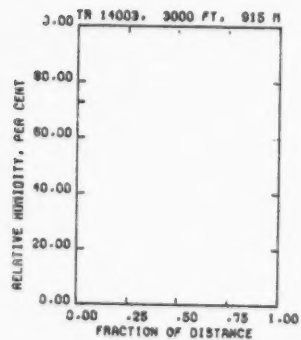
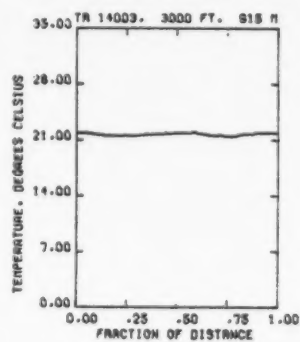
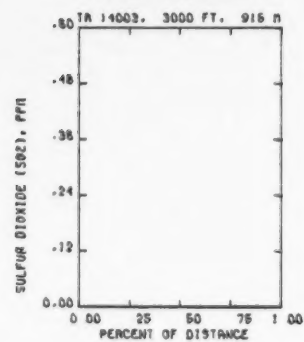
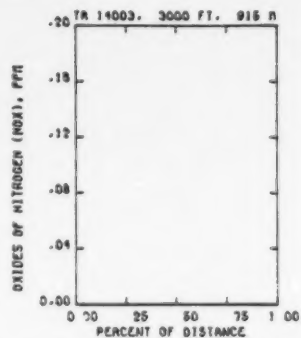
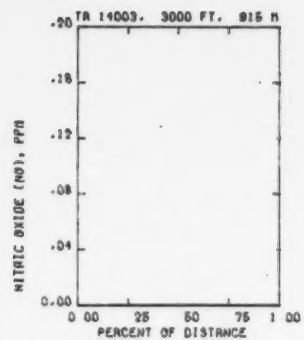




TR. 14003. 3000 FT. 915 N. POINTS -II- TO -I-

7/24/74. 16:42:38 TO 16:46:53. DISTANCE= 12.0 KM





BEGIN
FIRST
LINE OF
TEXT
HERE

TYPING GUIDE SHEET

CENTER
OF PAGE

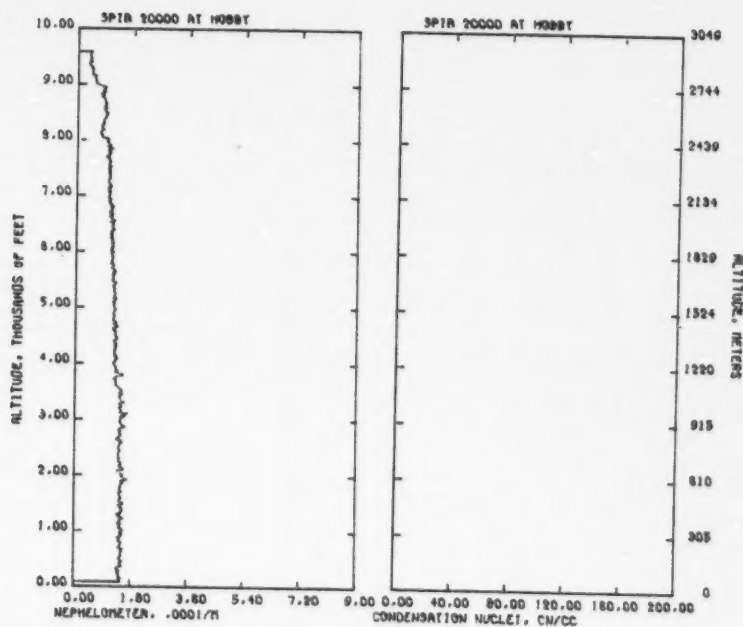
TOP OF
IMAGE
AREA

DROPPED
HEAD:
BEGIN
SECTION
HERE

SPIRAL 20000 AT HOBBY

80 TO 9580 FEET
24 TO 2921 METERS

7/18/74, 13: 8:36 TO 13:35:58, DISTANCE= 9500 FEET
2896 METERS



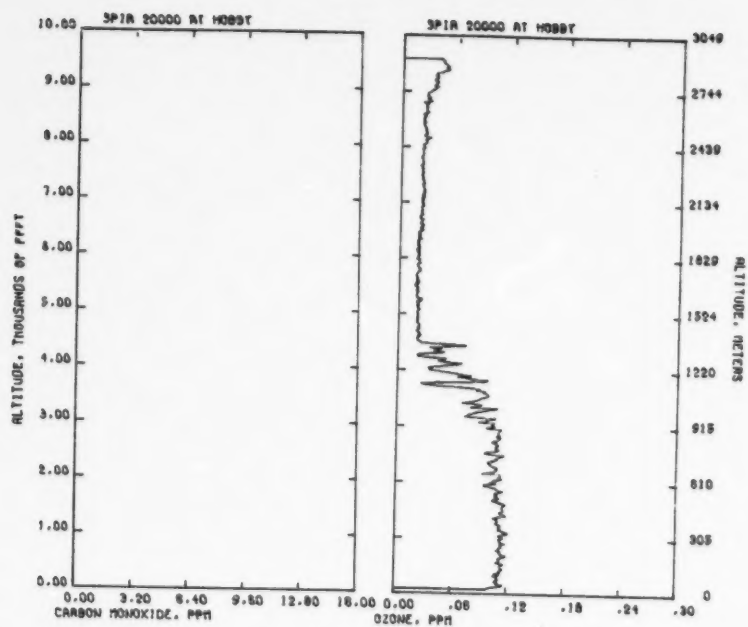
BEGIN
LAST LINE
OF TEXT

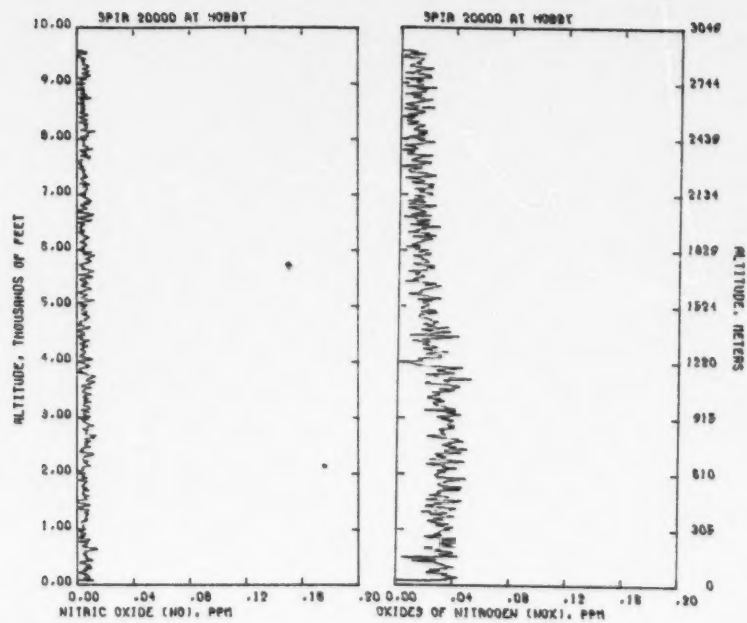
EPA-287 (Cir.)
(4-76)

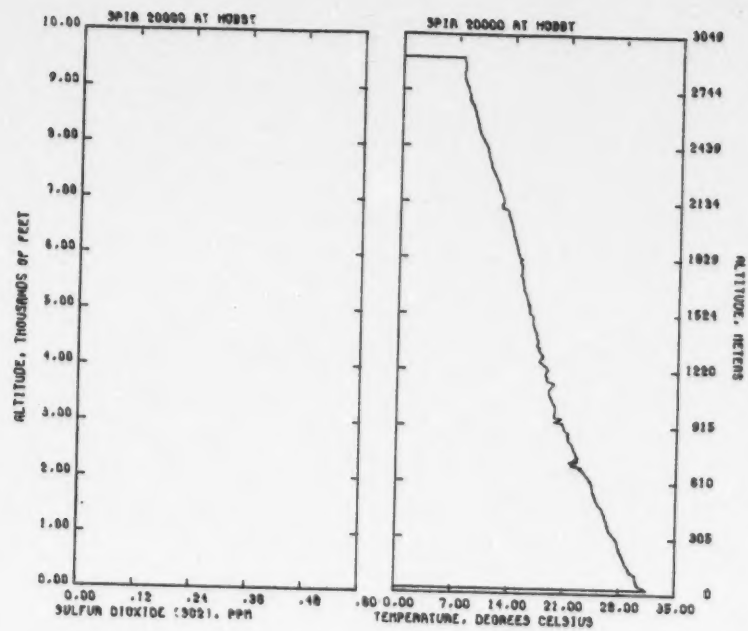
162

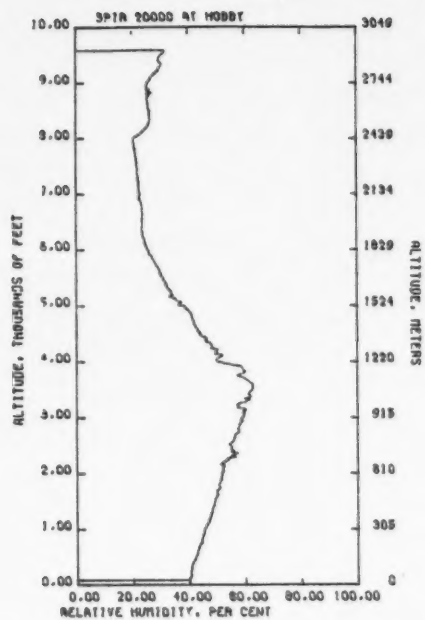
PAGE NUMBER

BOTTOM OF
IMAGE AREA,
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUSTRATIONS







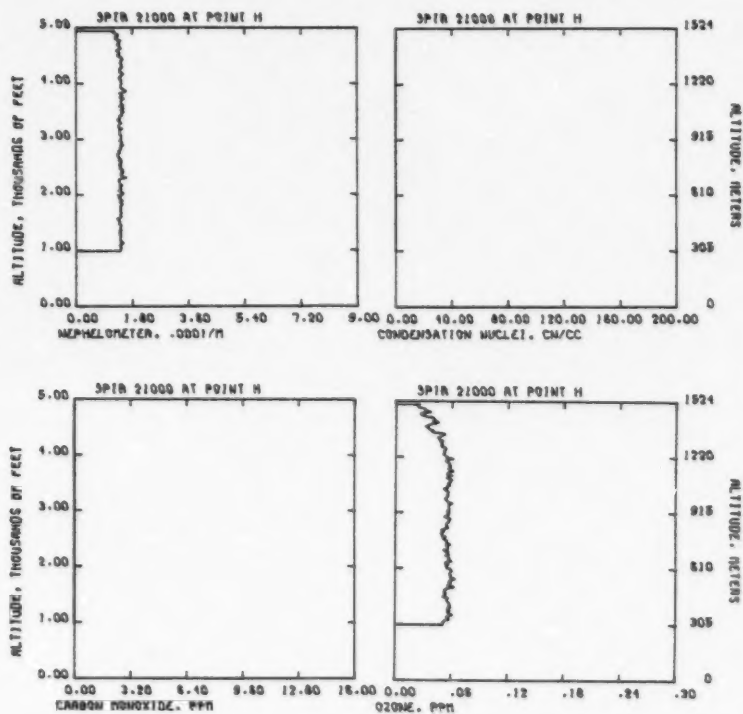


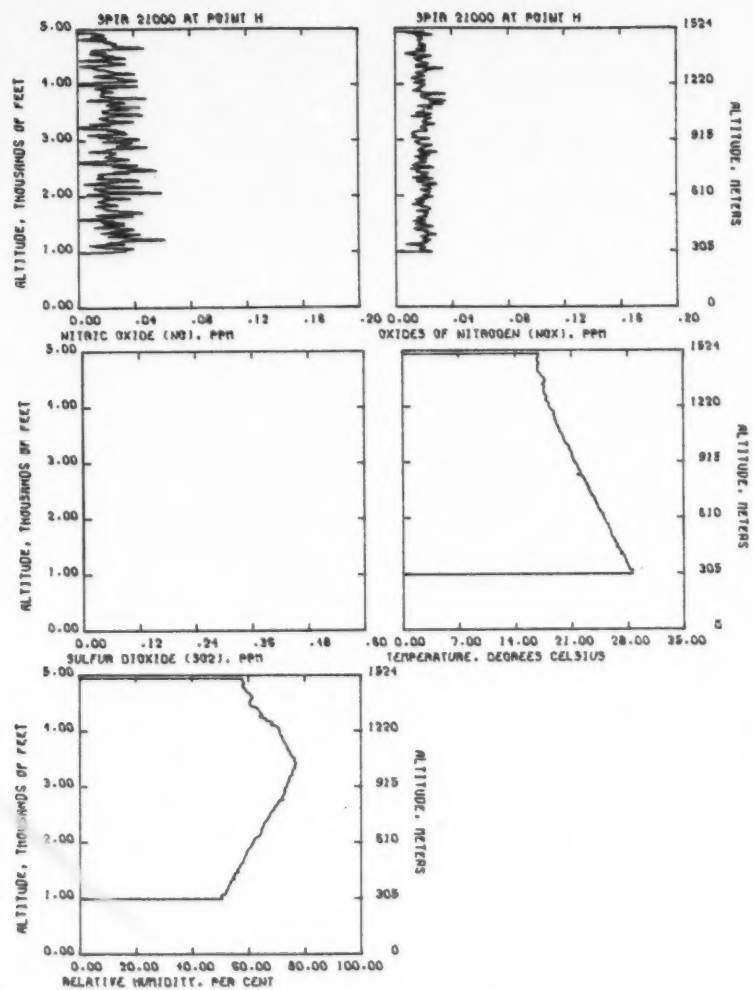
SPIRAL 21000 AT POINT H

980 TO 4940 FEET

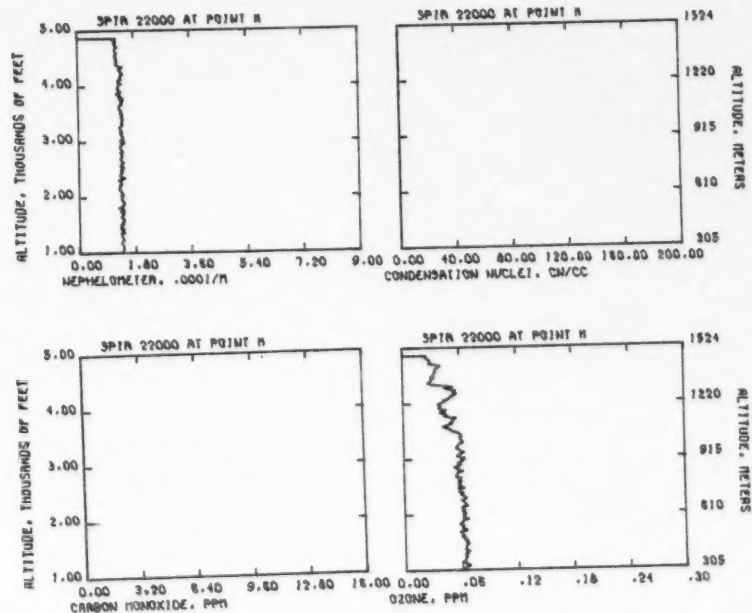
299 TO 1506 METERS

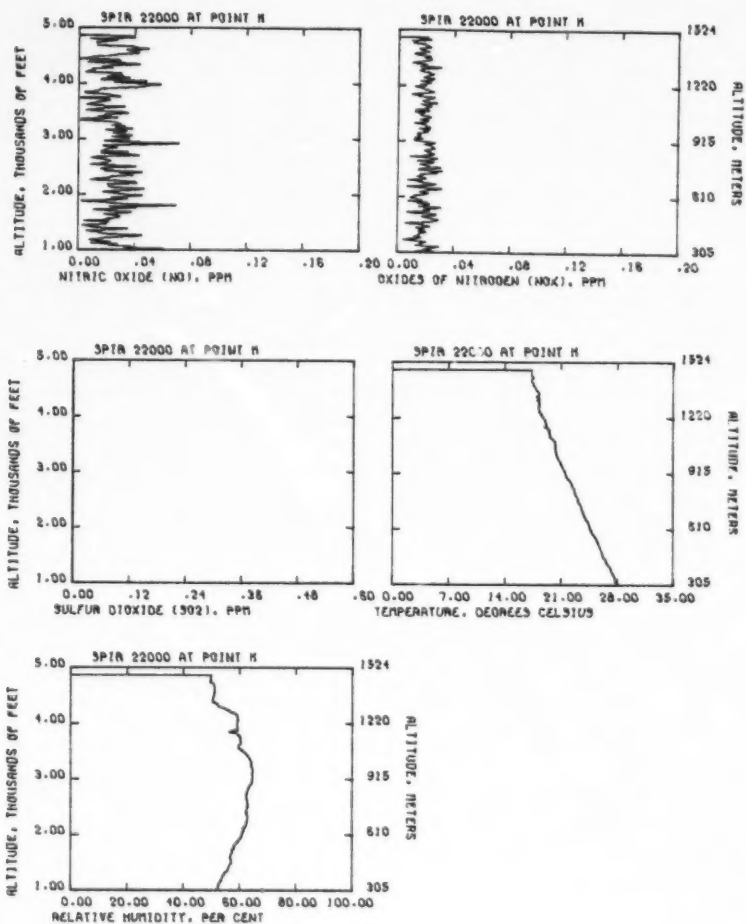
7/18/74, 14:51:30 TO 15: 0:24, DISTANCE= 3960 FEET
1207 METERS





SPIRAL 22000 AT POINT H 1000 TO 4860 FEET
 305 TO 1482 METERS
 7/18/74, 16.18.39 TO 16.26.19, DISTANCE= 3860 FEET
 1177 METERS

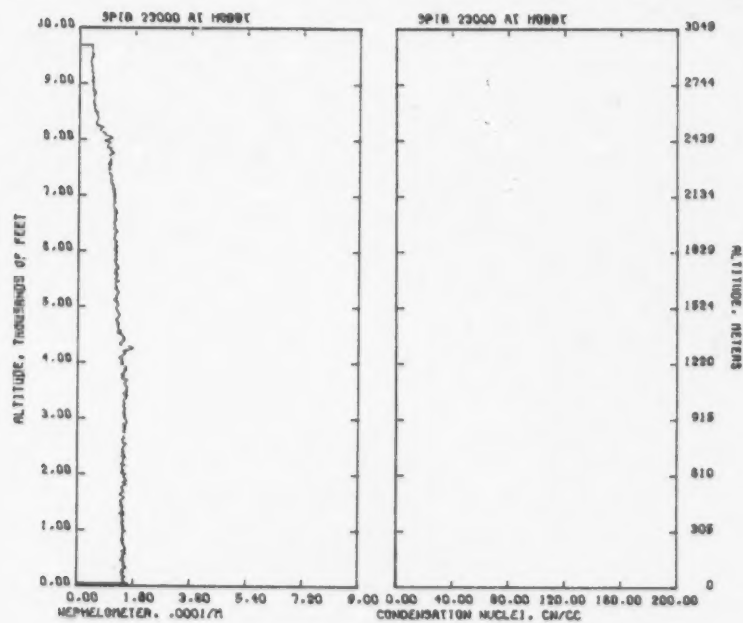


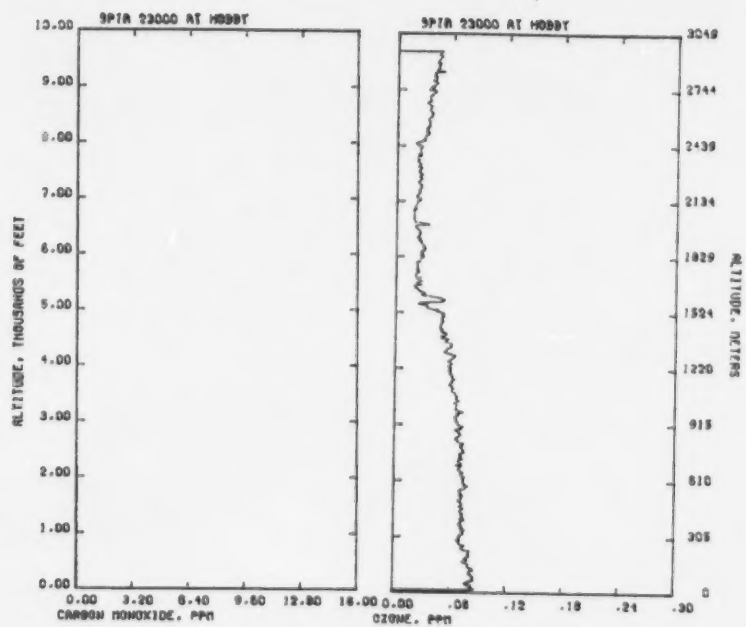


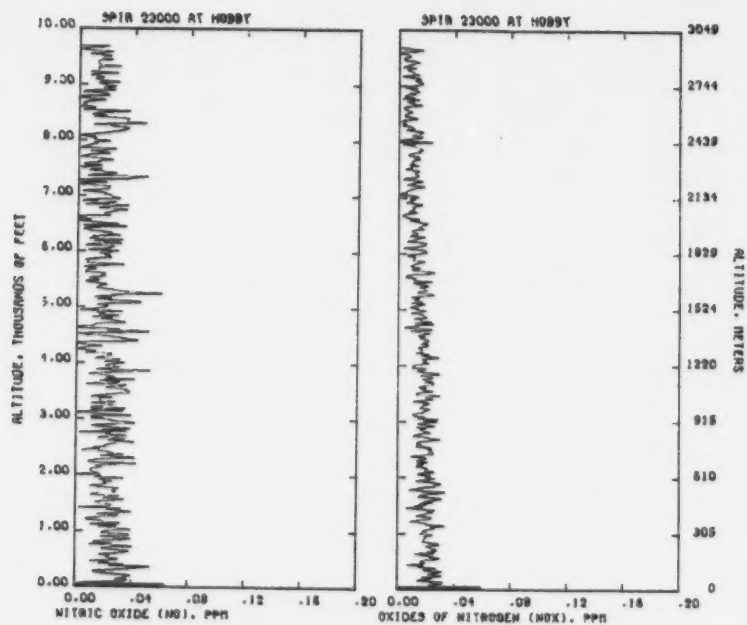
SPIRAL 23000 AT HOBBS

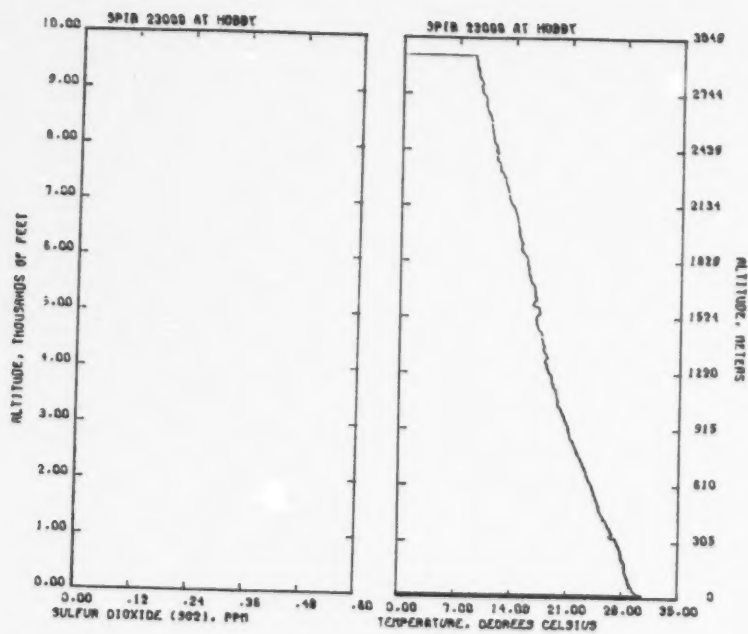
40 TO 9680 FEET
12 TO 2951 METERS

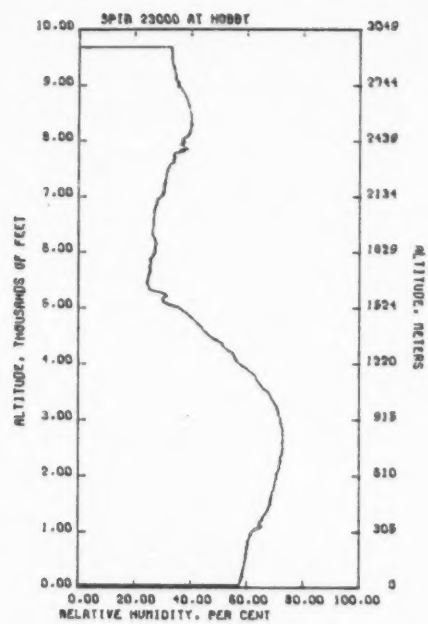
7/18/74, 16:51:19 TO 17:10:31, DISTANCE= 9640 FEET
2939 METERS







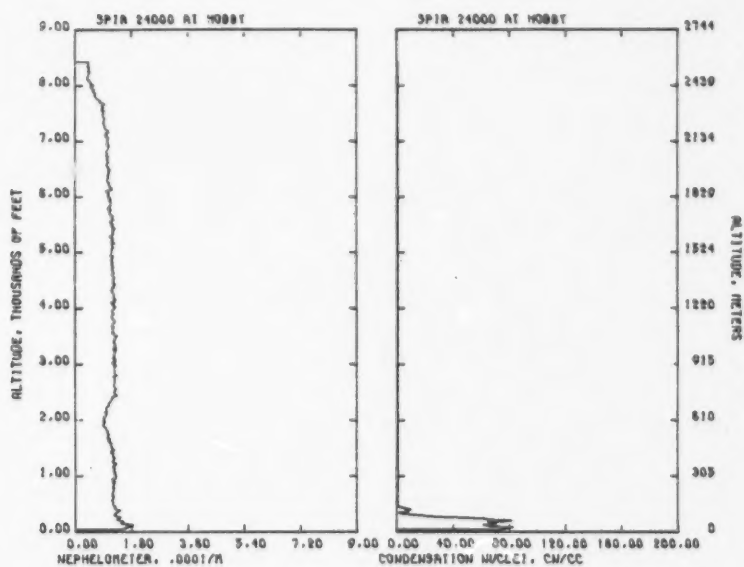


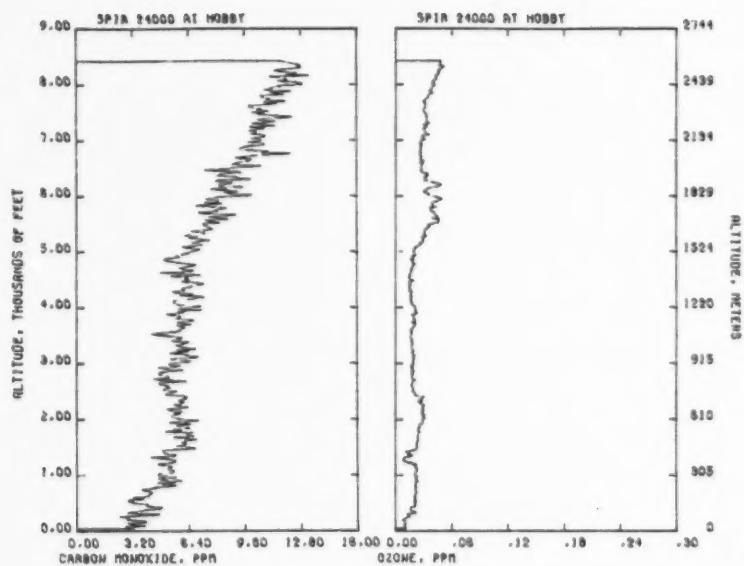


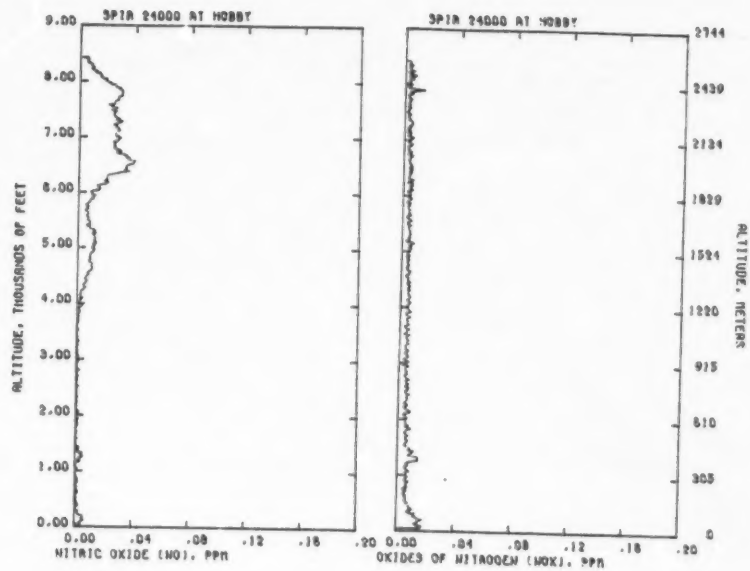
SPIRAL 24000 AT HOBBY

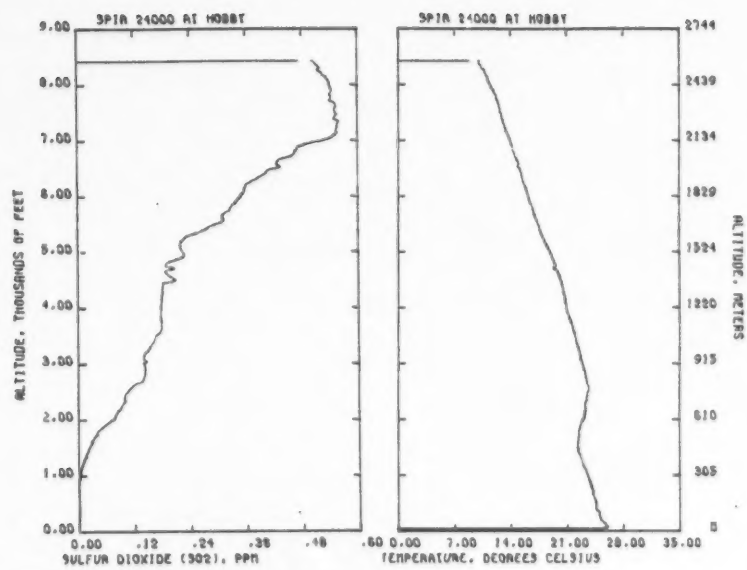
40 TO 8420 FEET
12 TO 2567 METERS

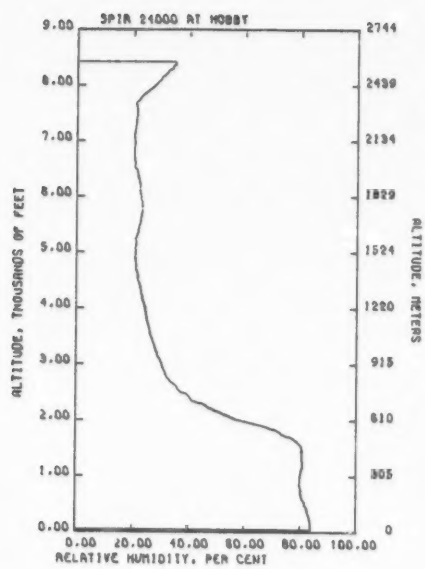
7/19/74, 8:45:58 TO 9: 8:44, DISTANCE= 9390 FEET
2555 METERS







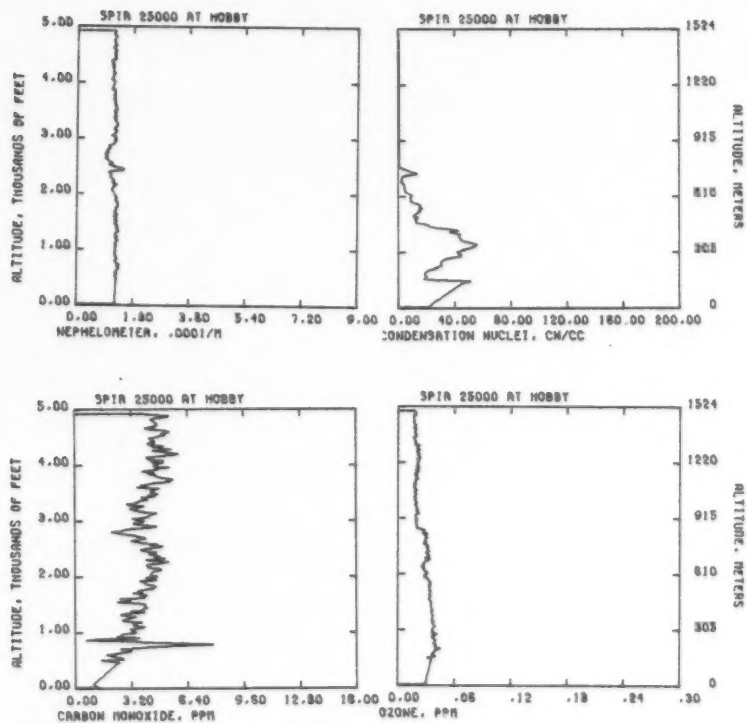


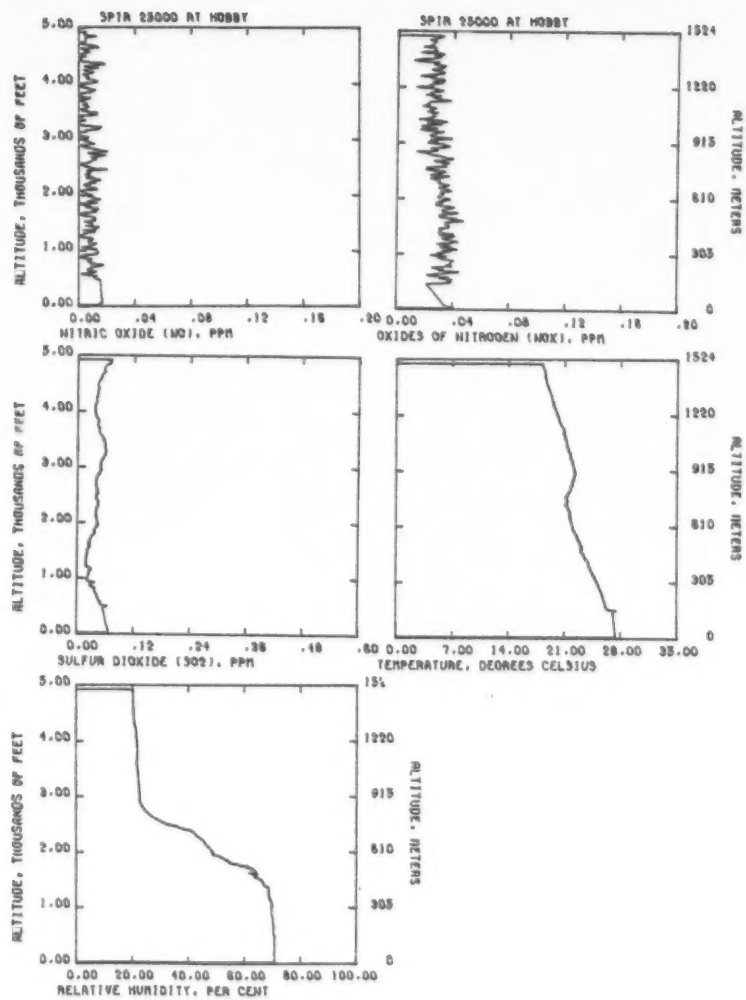


SPIRAL 25000 AT HOBBY

20 TO 4920 FEET
6 TO 1500 METERS

7/17/74, 10:59:10 TO 11:08:11, DISTANCE= 4900 FEET
1494 METERS



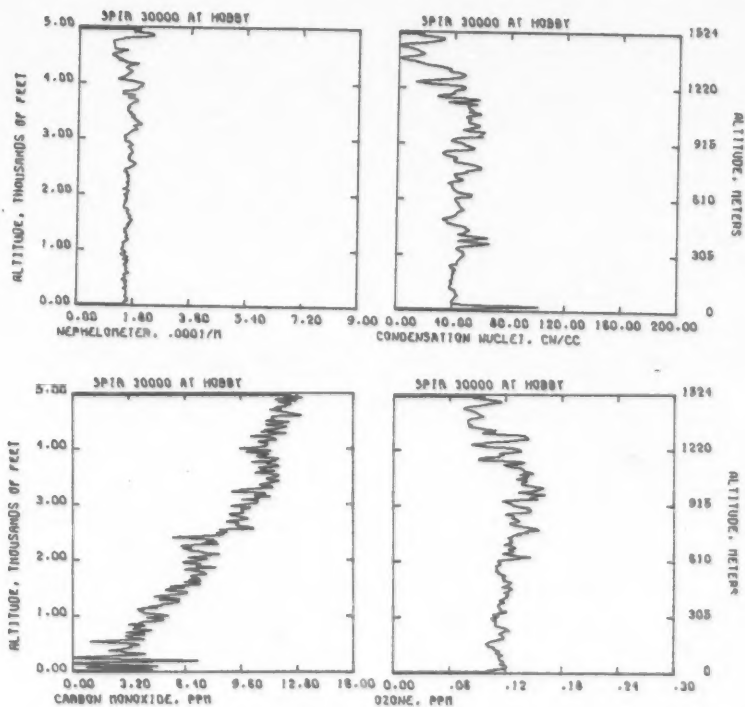


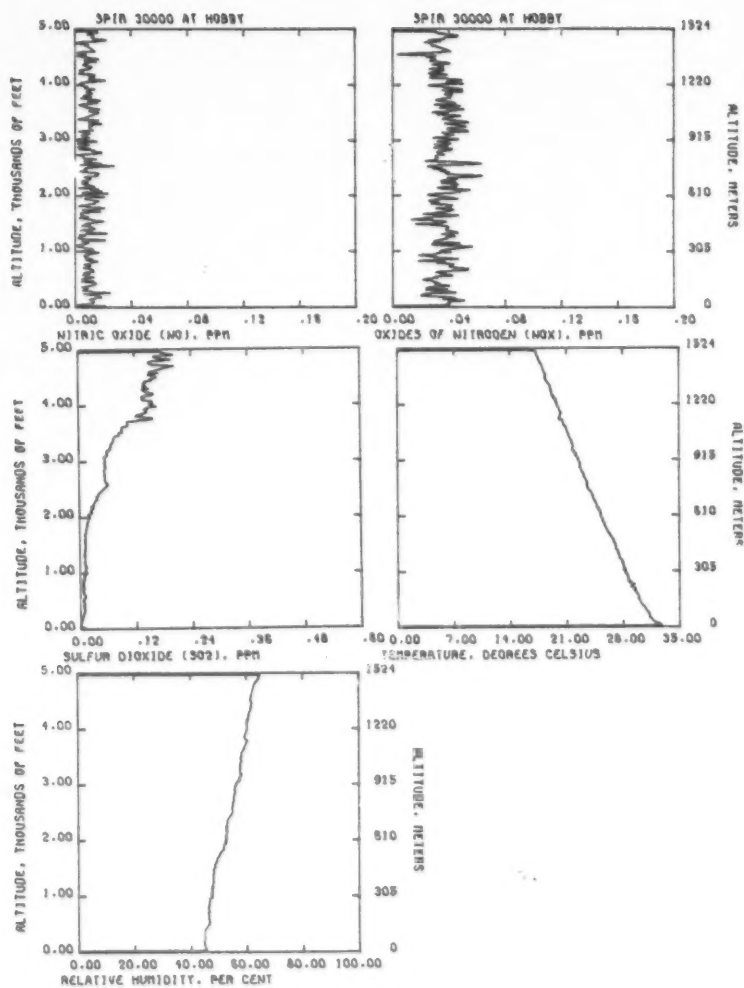
SPIRAL 30000 AT HOBBY

20 TO 4960 FEET

6 TO 1512 METERS

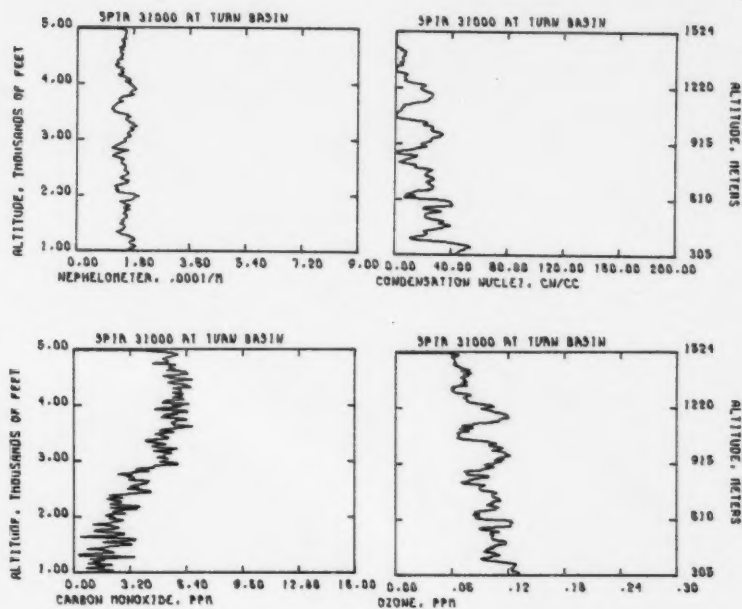
7/20/74, 13:22:55 TO 13:36:16, DISTANCE= 4940 FEET
1506 METERS

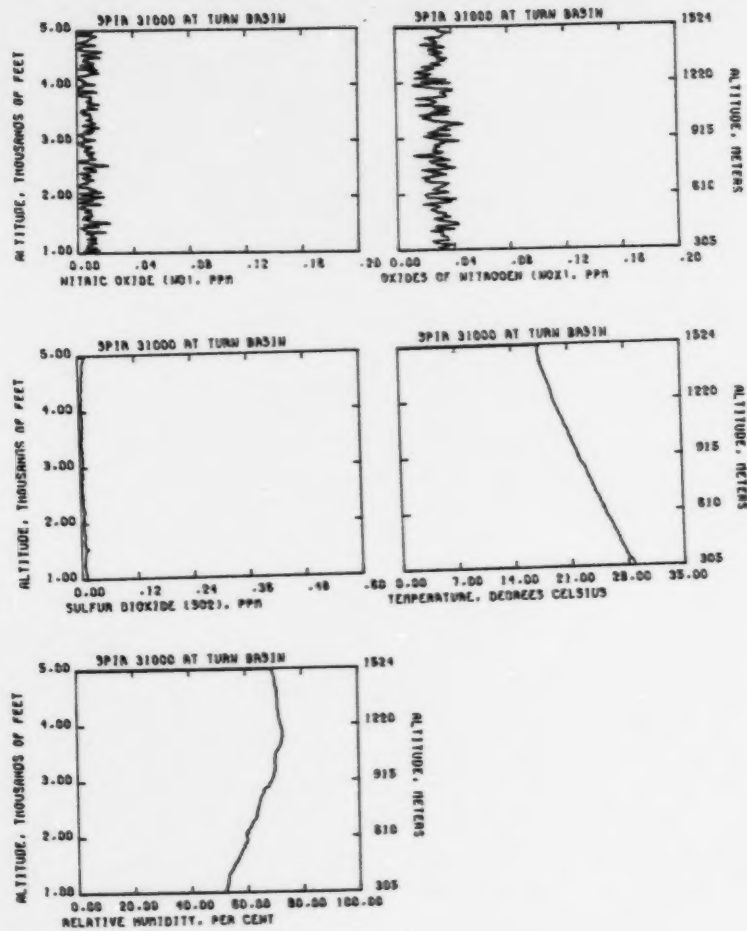




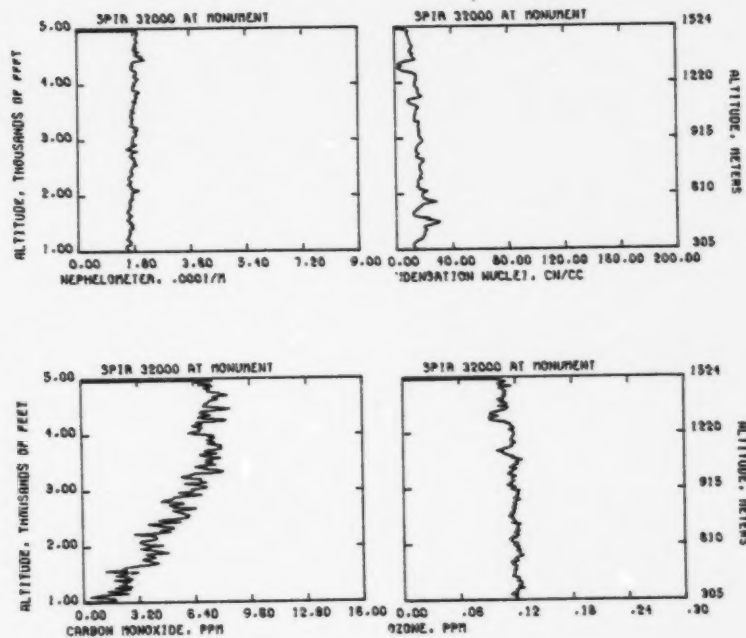
SPIRAL 31000 AT TURN BASIN 1000 TO 4980 FEET
305 TO 1518 METERS

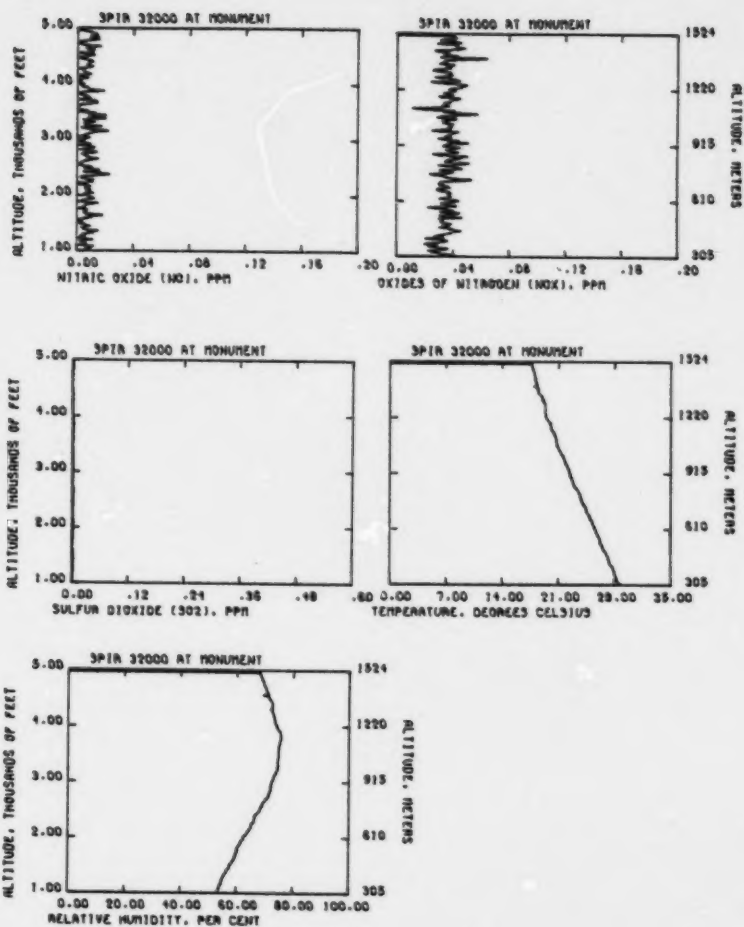
7/20/74, 14:22:46 TO 14:30:27, DISTANCE= 3980 FEET
1213 METERS





SPIRAL 32000 AT MONUMENT 1000 TO 4960 FEET
 305 TO 1612 METERS
 7/20/74, 15:51:44 TO 15:59:48, DISTANCE= 3960 FEET
 1207 METERS

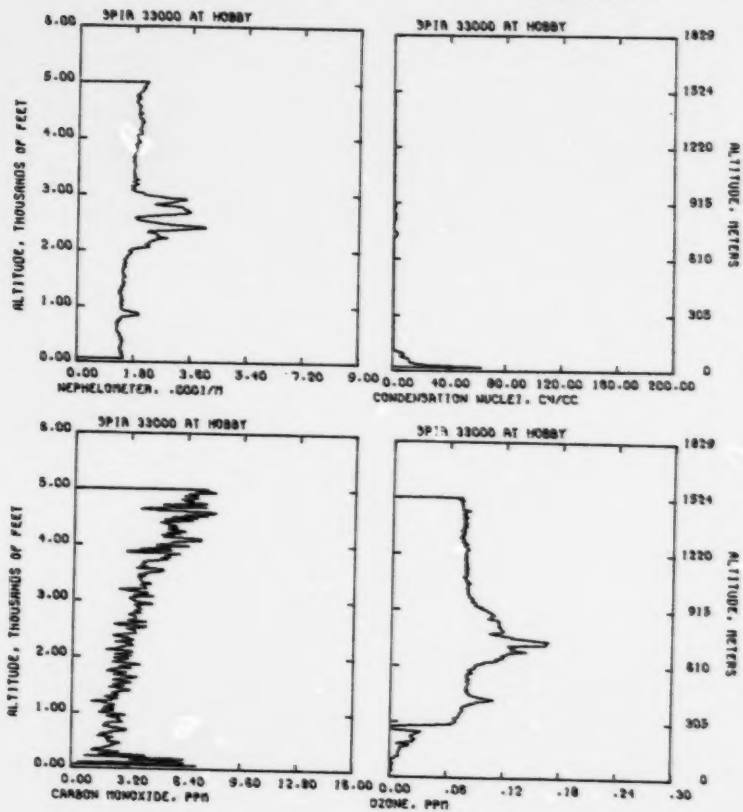


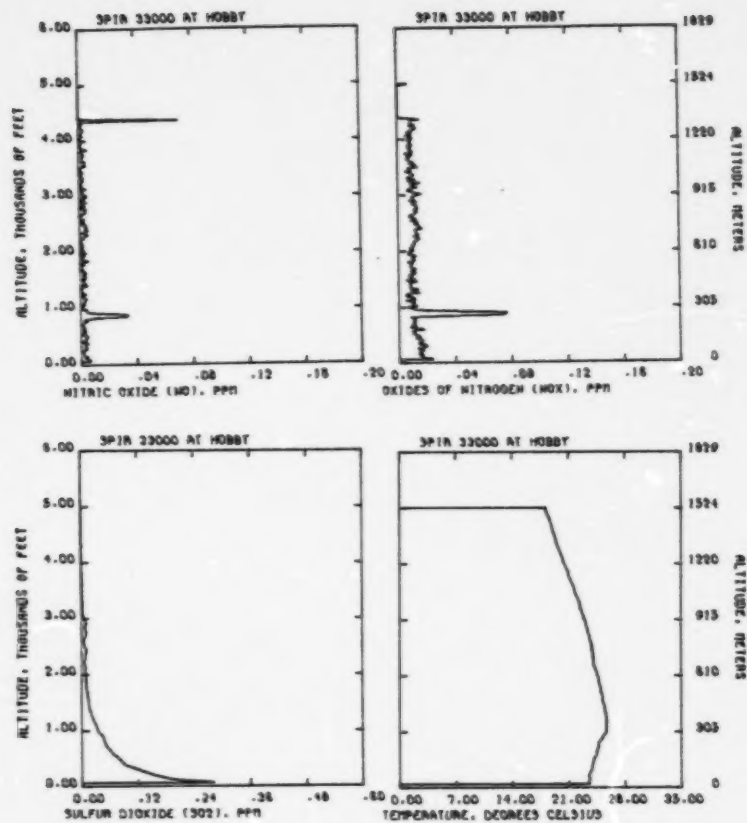


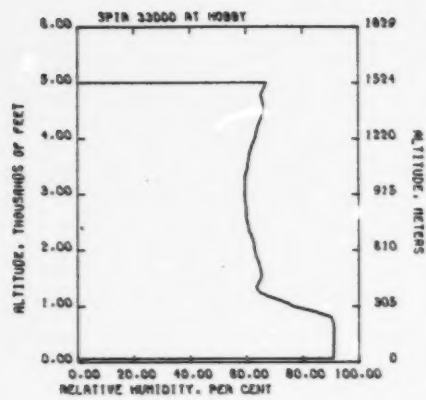
SPIRAL 33000 AT HOBBY

60 TO 5000 FEET
18 TO 1524 METERS

7/21/74, 6:10:41 TO 6:24:2. DISTANCE= 5940 FEET
1506 METERS

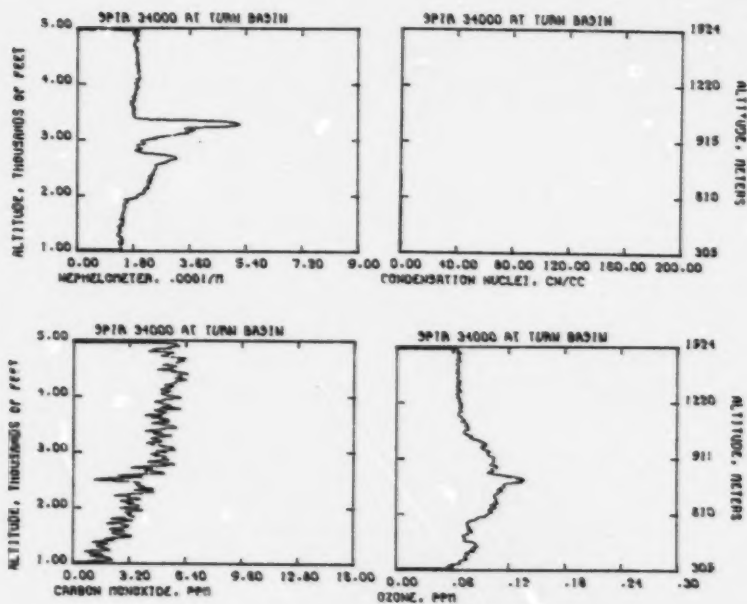


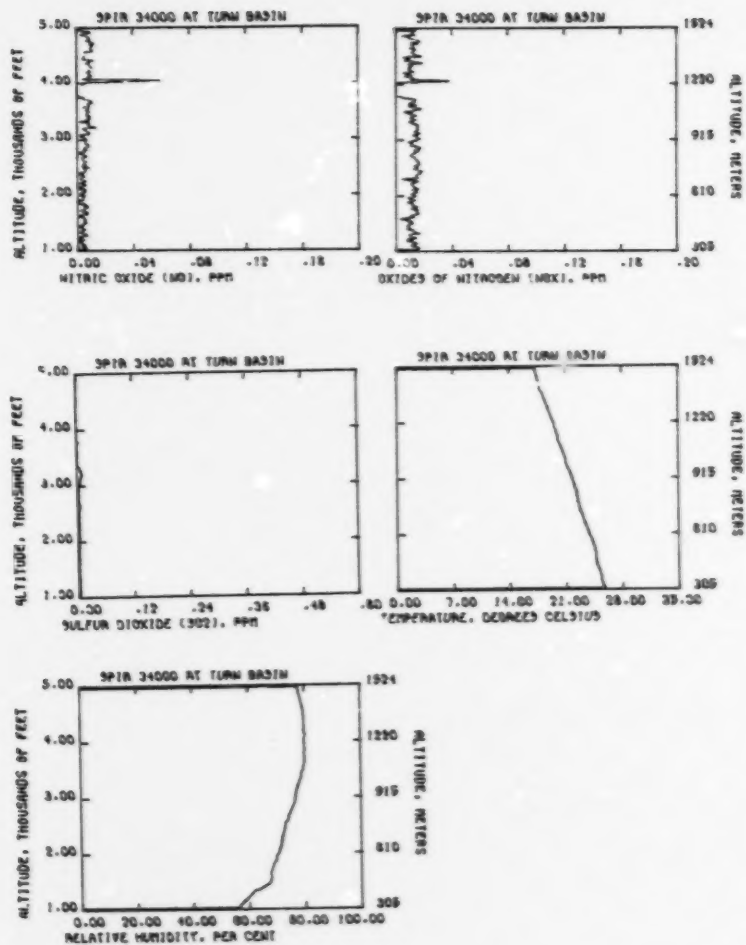




SPIRAL 34000 AT TURN BASIN 1020 TO 4960 FEET
311 TO 1512 METERS

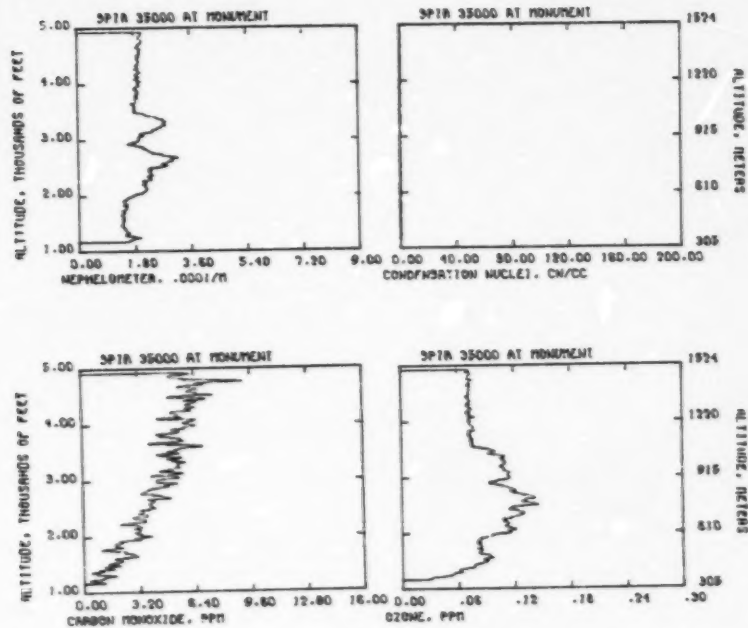
7/21/74, 7:15:14 TO 7:23:50, DISTANCE= 3940 FEET
1201 METERS

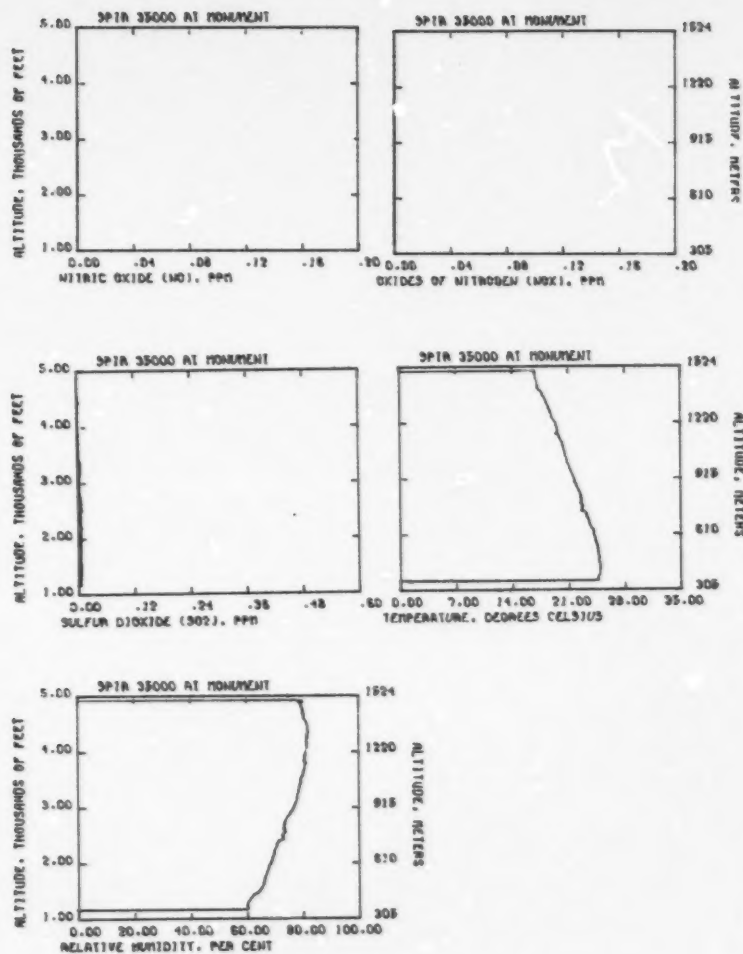




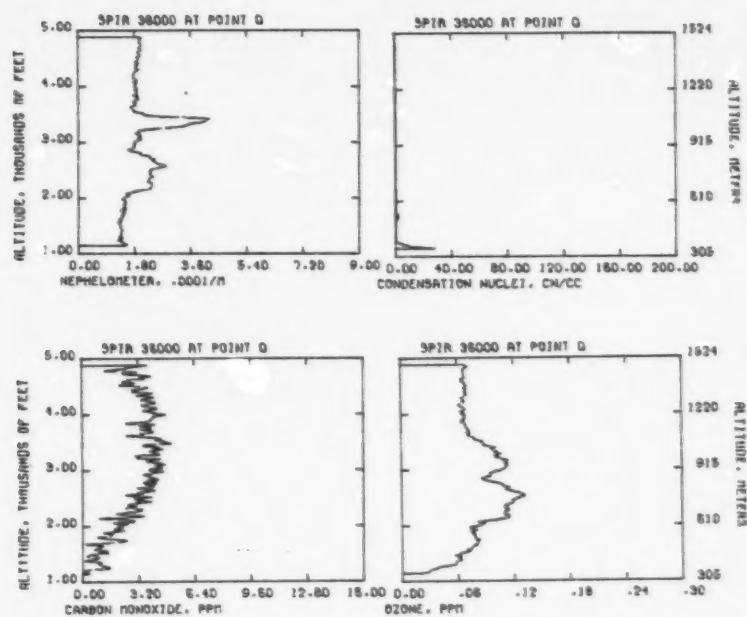
SPIRAL 35000 AT MONUMENT 1160 TO 4920 FEET
354 TO 1500 METERS

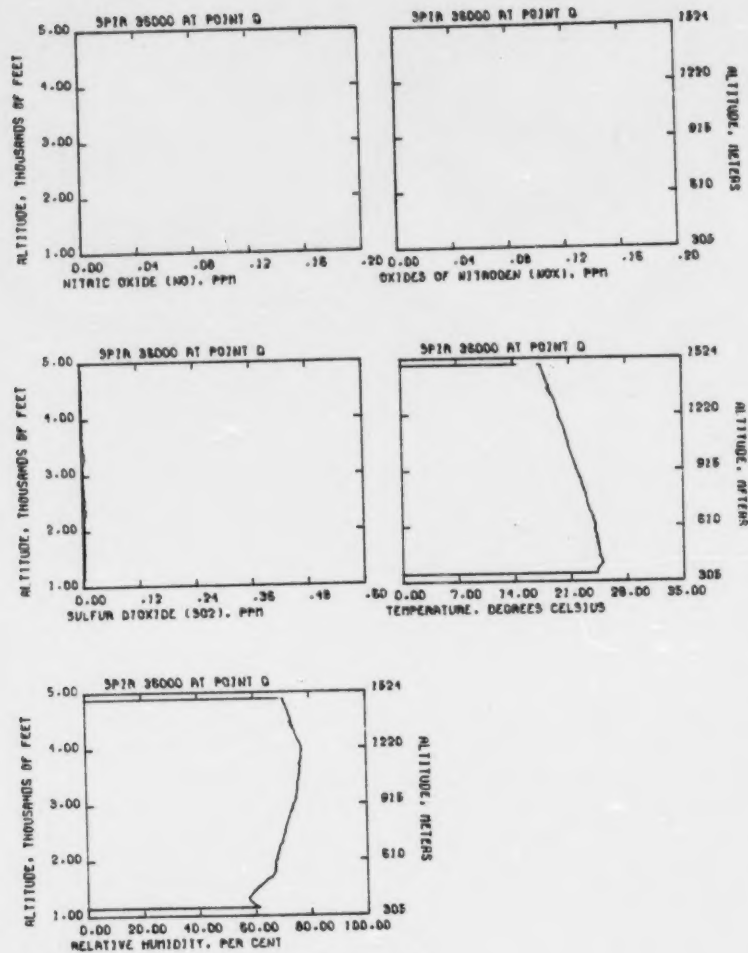
7/21/74. 8:48:53 TO 8:57:2. DISTANCE= 3760 FEET
1146 METERS





SPIRAL 36000 AT POINT Q 1140 TO 4880 FEET
 348 TO 1488 METERS
 7/21/74, 9: 6:39 TO 9:14:28, DISTANCE= 3740 FEET
 1140 METERS

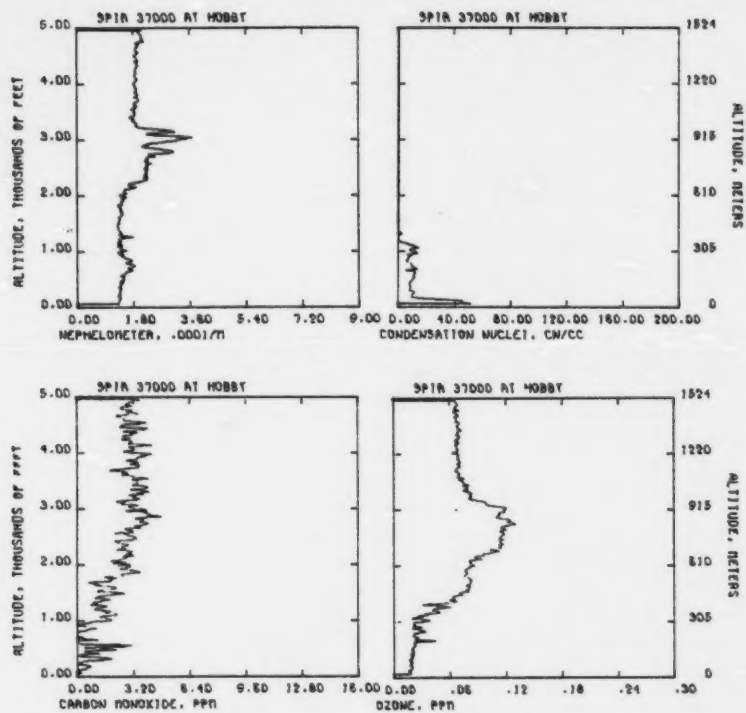


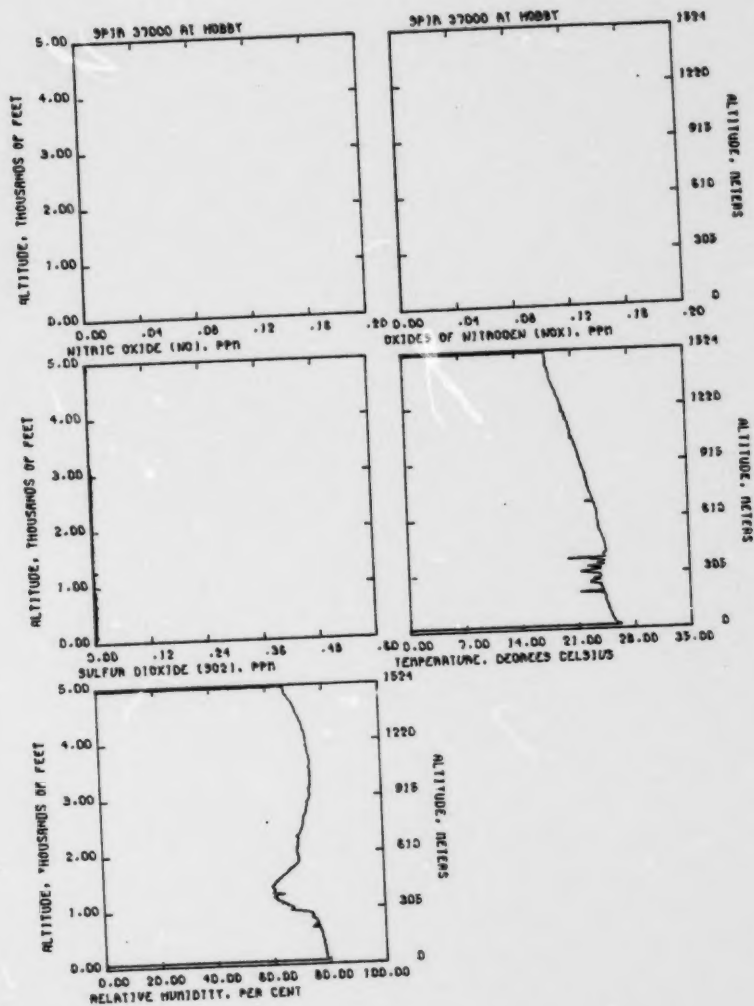


SPIRAL 37000 AT HOBBS

60 TO 4960 FEET
18 TO 1512 METERS

7/21/74, 9.23.14 TO 9.33.23, DISTANCE= 4900 FEET
1494 METERS

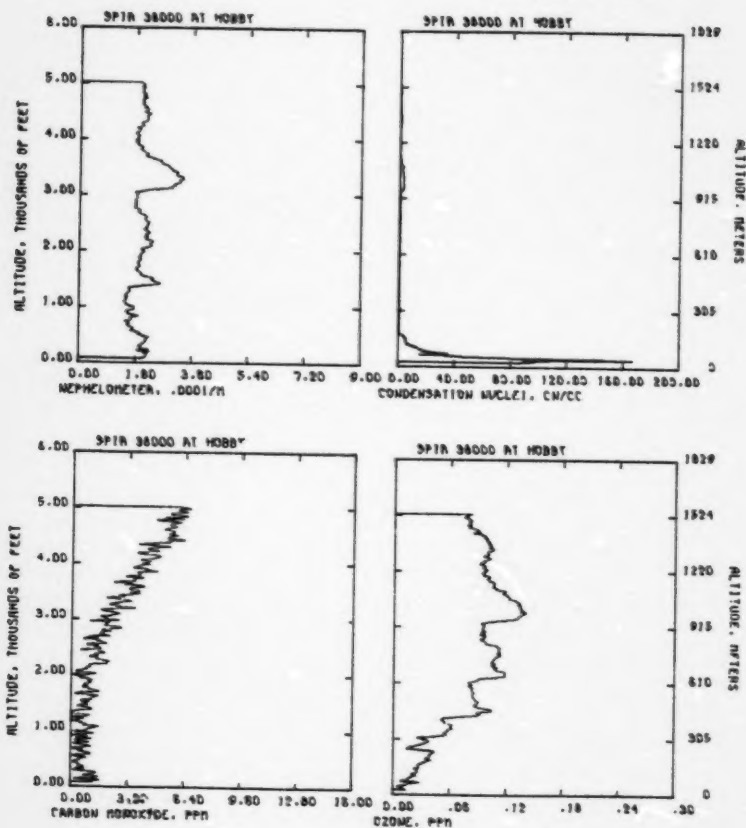


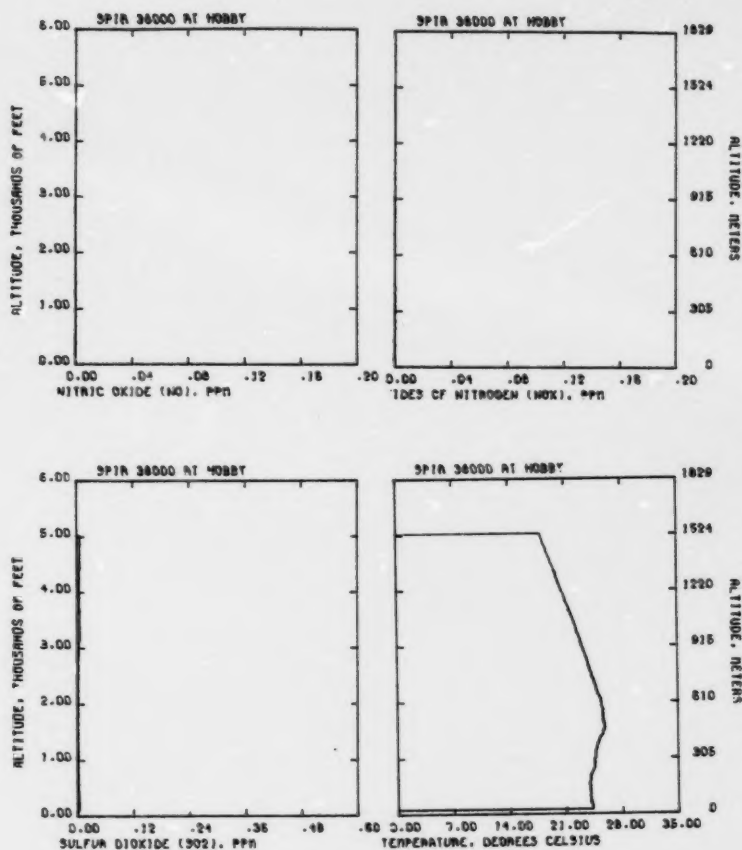


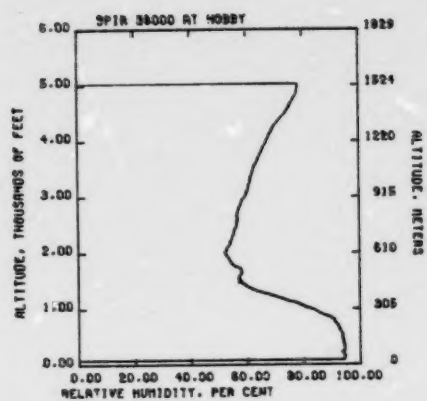
SPIRAL 38000 AT HOBBY

80 TO 5020 FEET
24 TO 1530 METERS

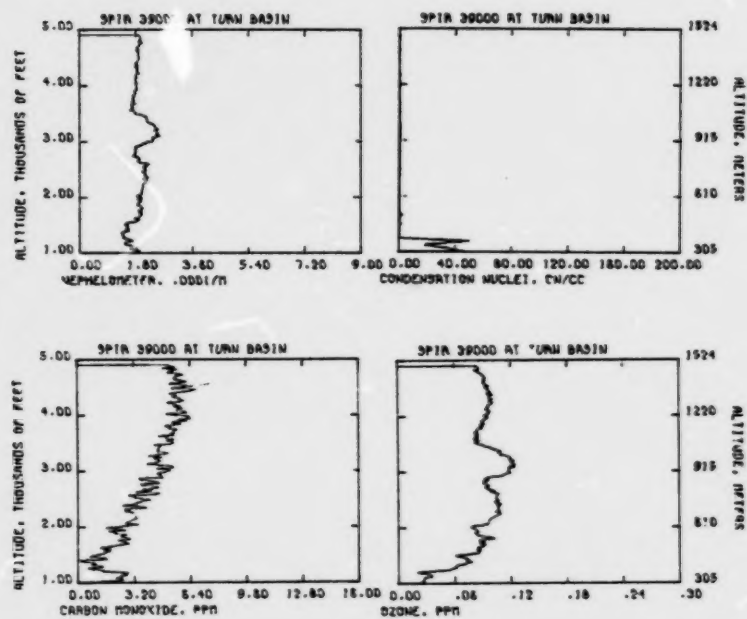
7/22/74. 7:31.19 TO 7:18.13. DISTANCE= 4940 FEET
1506 METERS

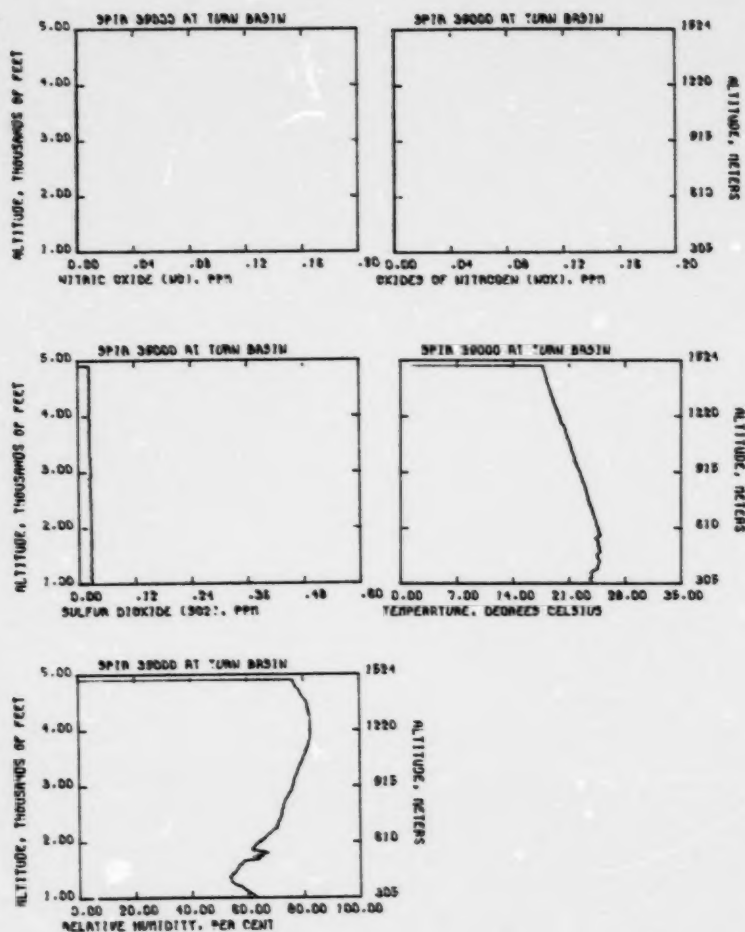






SPIRAL 39000 AT TURN BASIN 1000 TO 4900 FEET
 305 TO 1494 METERS
 7/22/74, 8:36:44 TO 8:44:39, DISTANCE= 3900 FEET
 1189 METERS

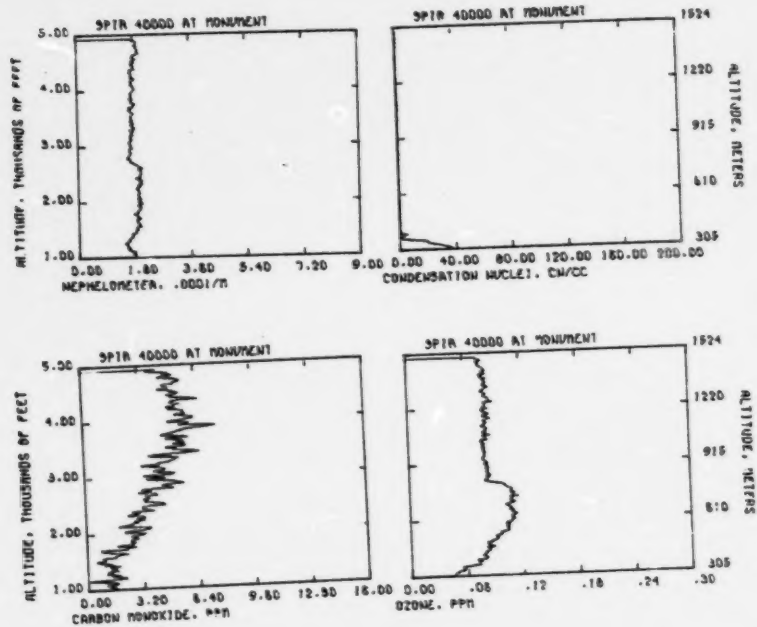


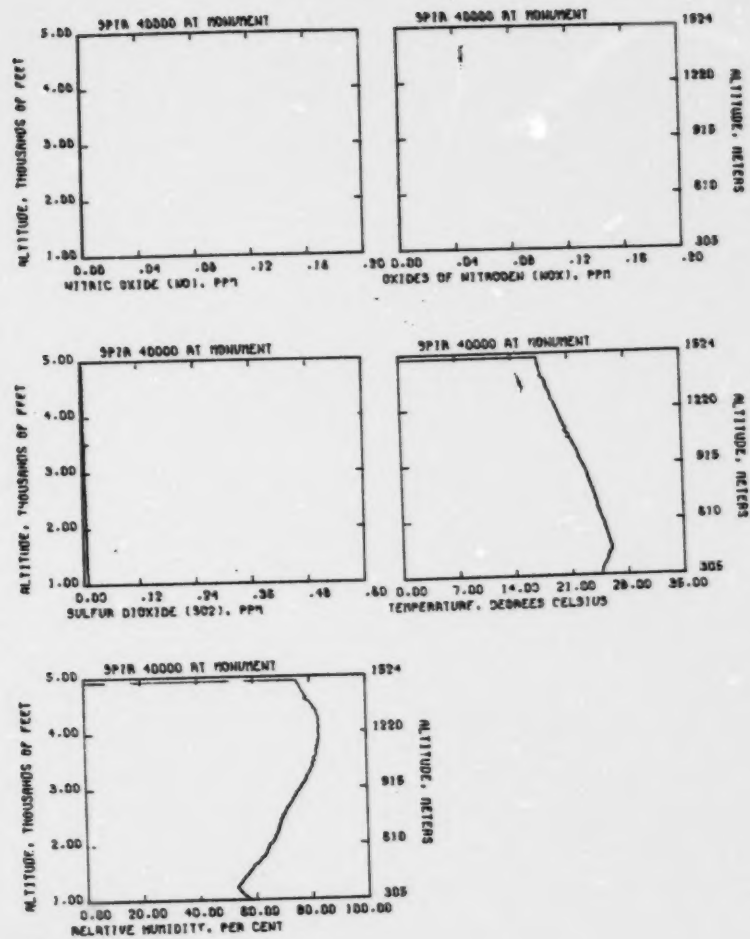


SPIRAL 40000 AT MONUMENT

1000 TO 4920 FEET
305 TO 1500 METERS

7/22/74, 10: 6.49 TO 10:14.36. DISTANCE = 3910 FEET
1195 METERS

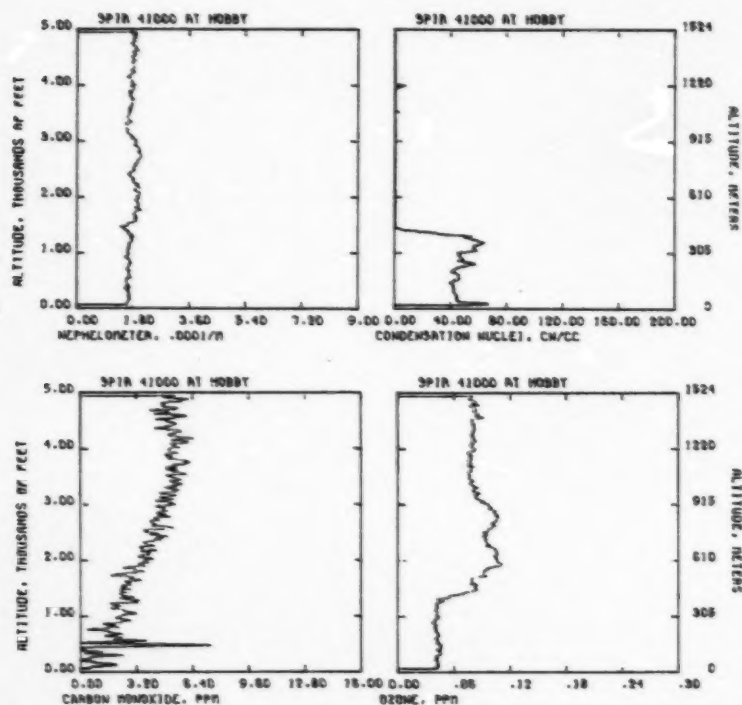


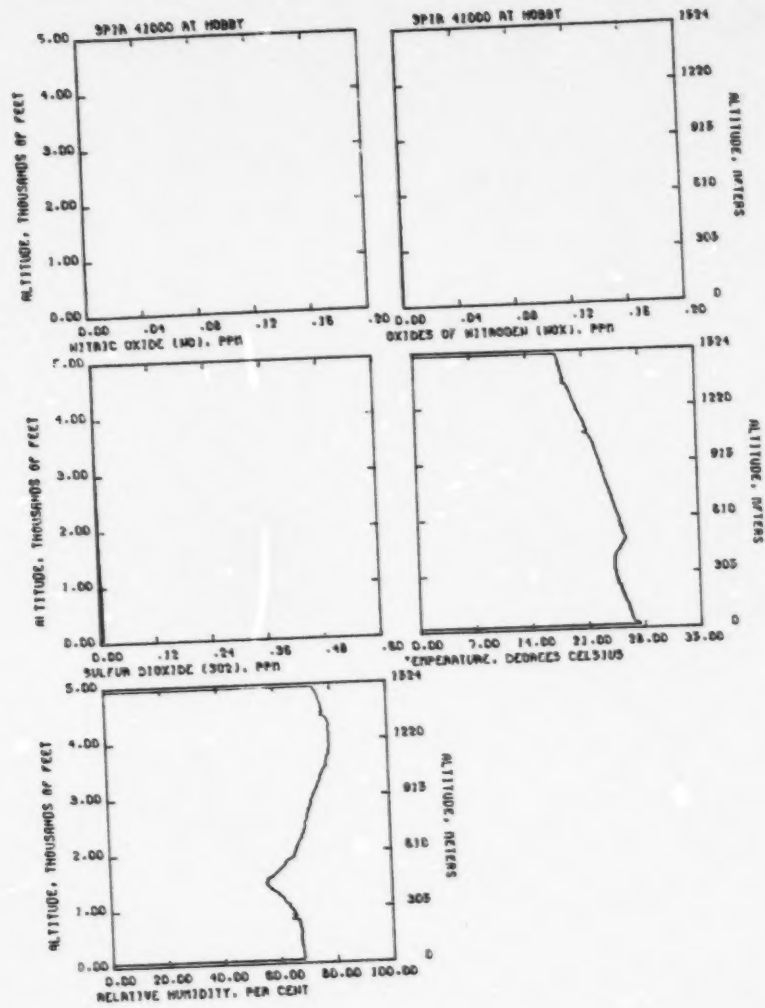


SPIRAL 41000 AT HOBBY

60 TO 4940 FEET
18 TO 1506 METERS

7/22/74. 10:26:28 TO 10:35:58. DISTANCE= 4880 FEET
1488 METERS

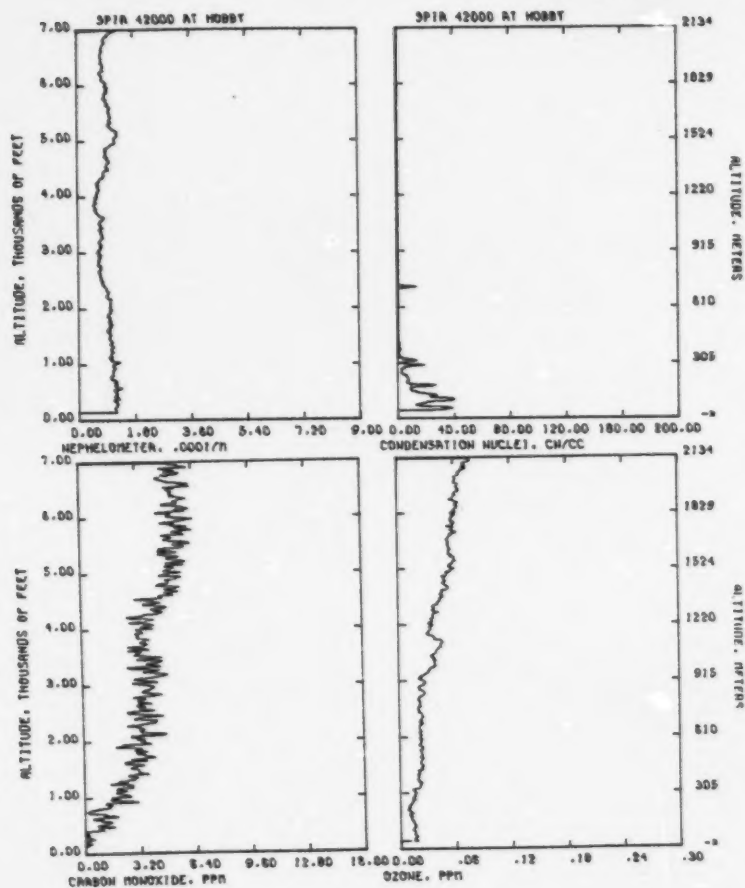


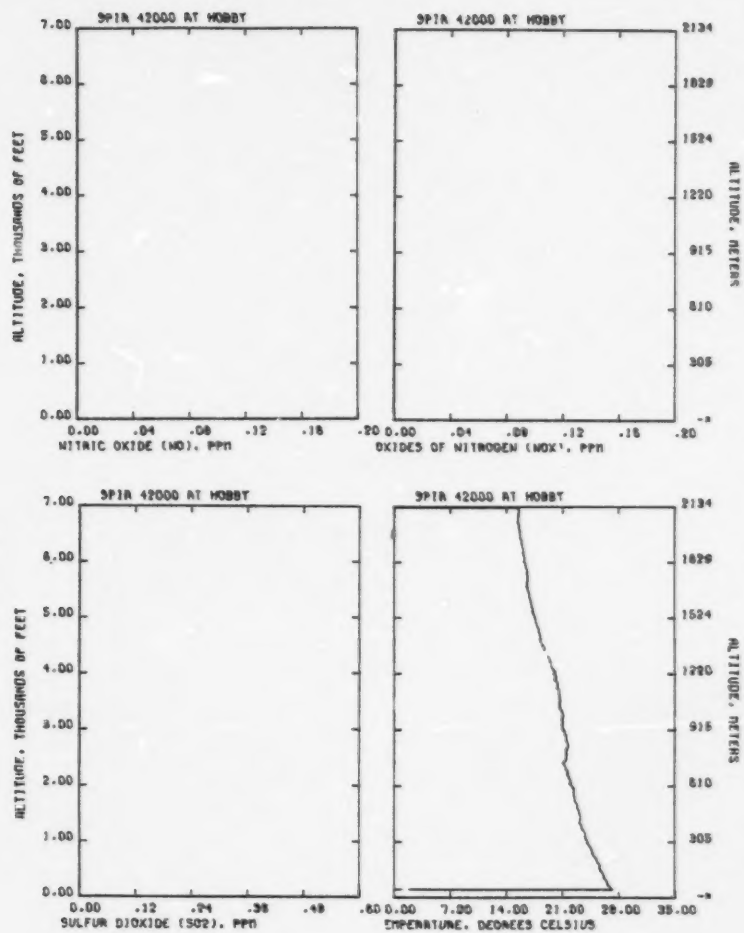


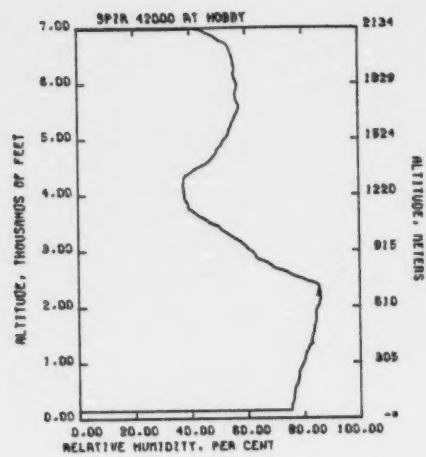
SPIRAL 42000 AT HOBBY

140 TO 6980 FEET
43 TO 2128 METERS

7/24/74. 9:26:57 TO 9:45:26. DISTANCE= 6940 FEET
2085 METERS





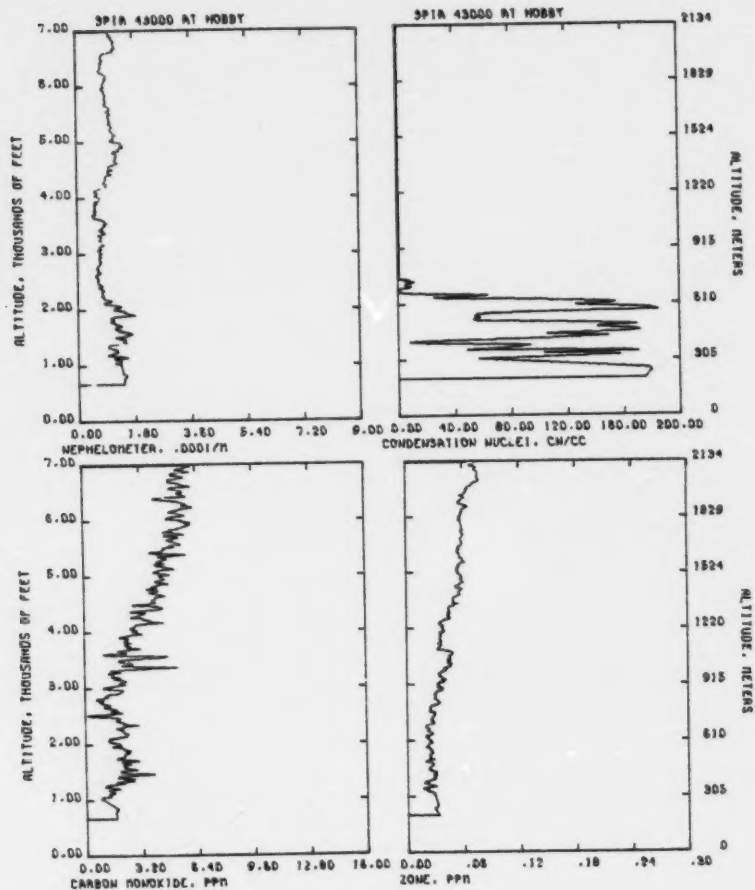


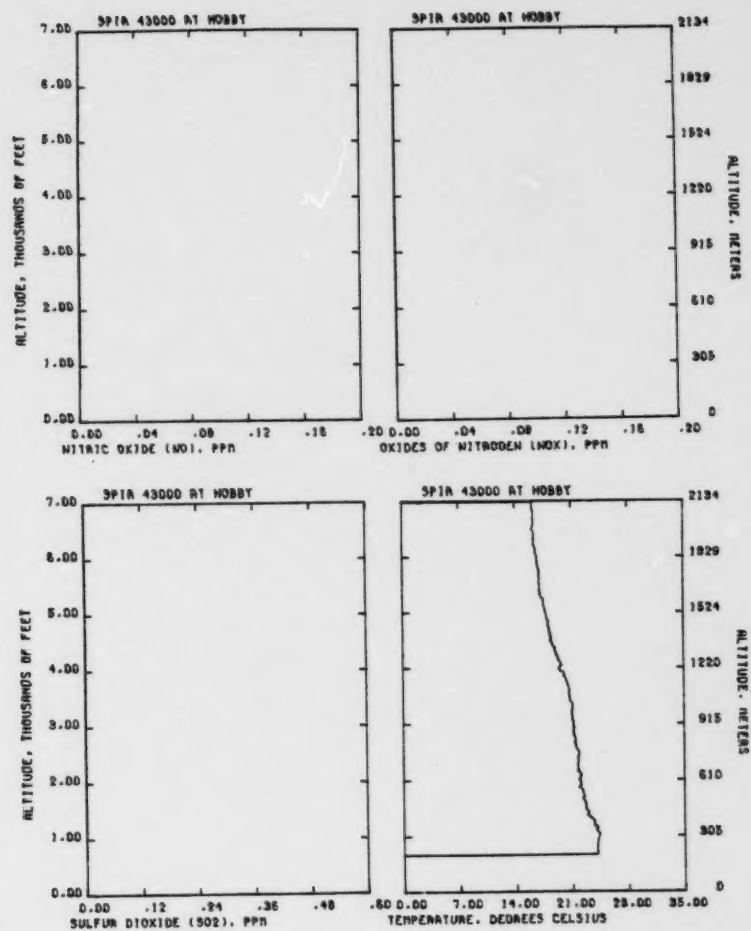
SPIRAL 43000 AT HOBBY

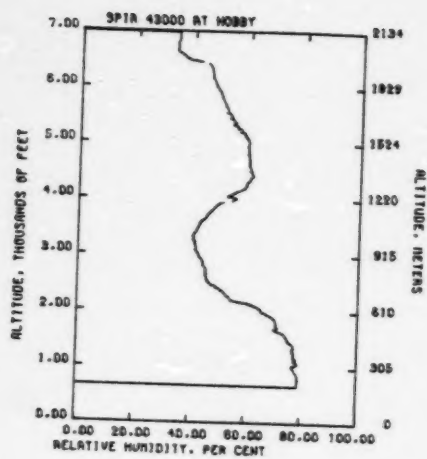
660 TO 6990 FEET

201 TO 2128 METERS

7/24/74, 9.53.9 TO 10.10.59, DISTANCE= 6320 FEET
1927 METERS



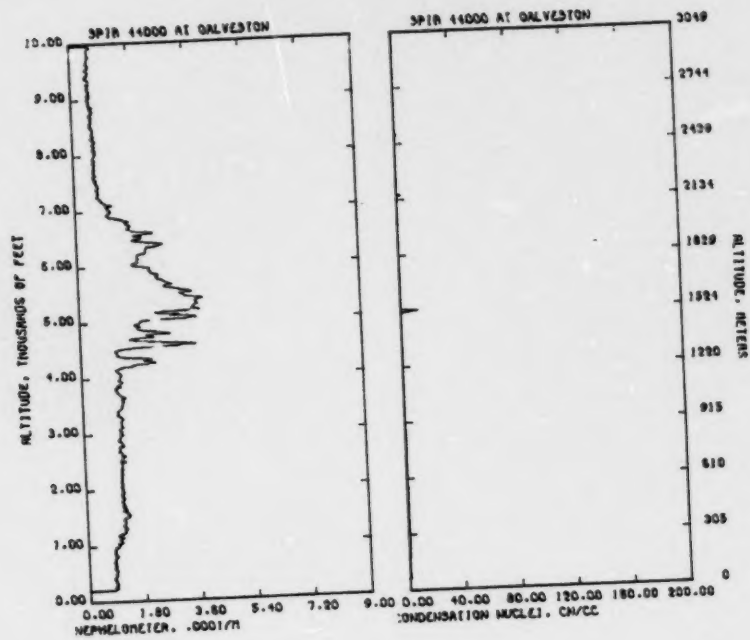


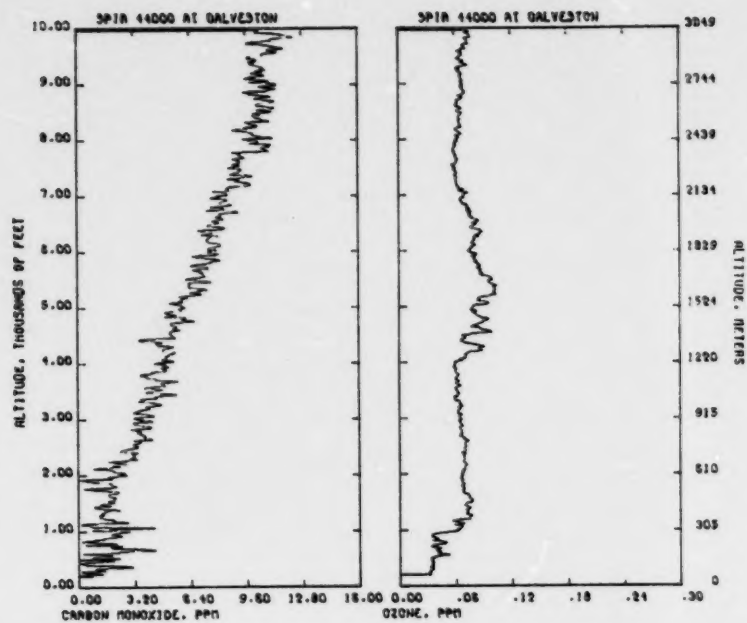


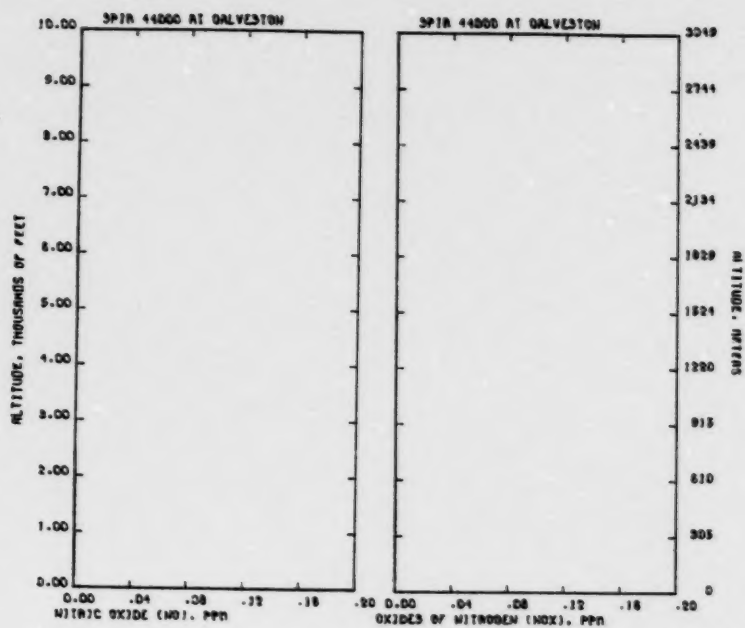
SPIRAL 44000 AT GALVESTON

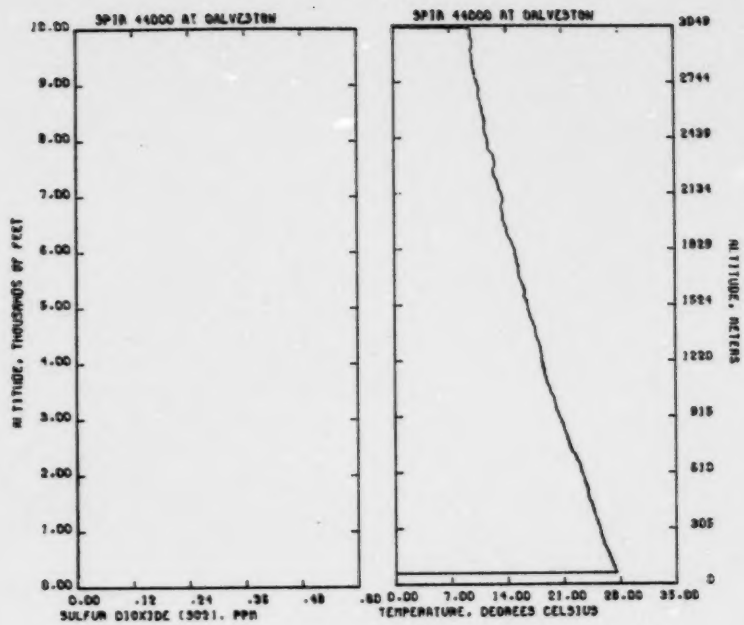
200 TO 9960 FEET
61 TO 3037 METERS

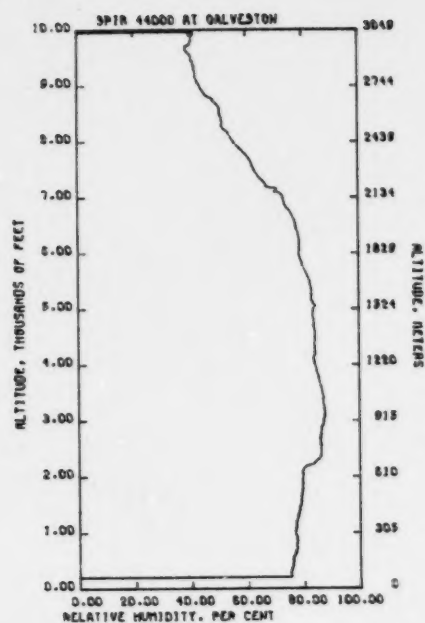
7/24/74, 14:43.58 TO 15:15.38, DISTANCE= 9760 FEET
2976 METERS



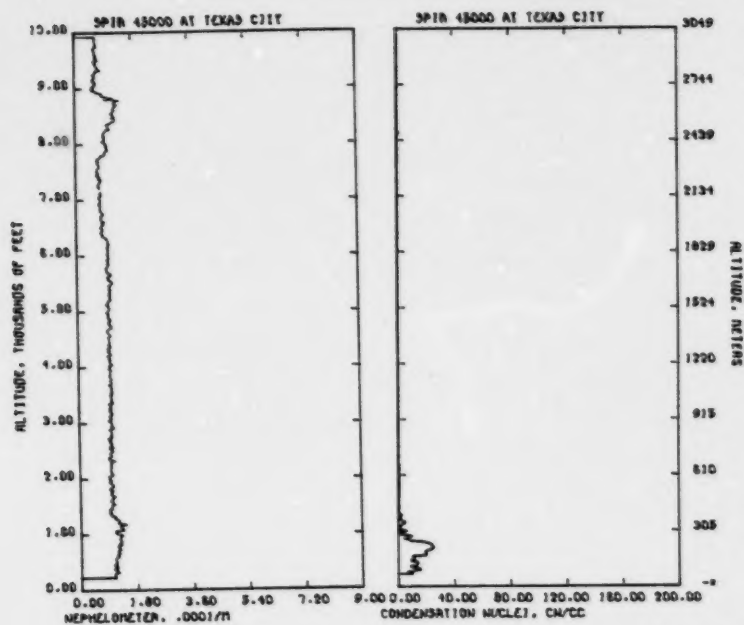


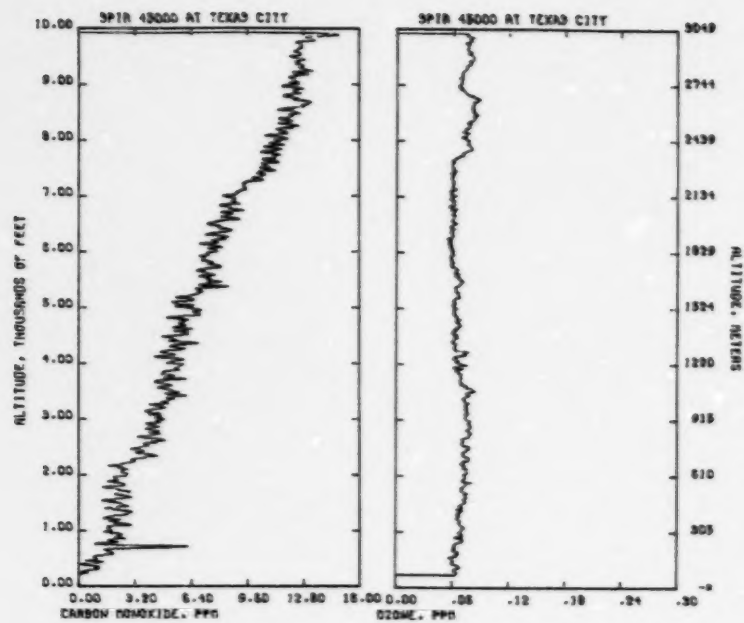


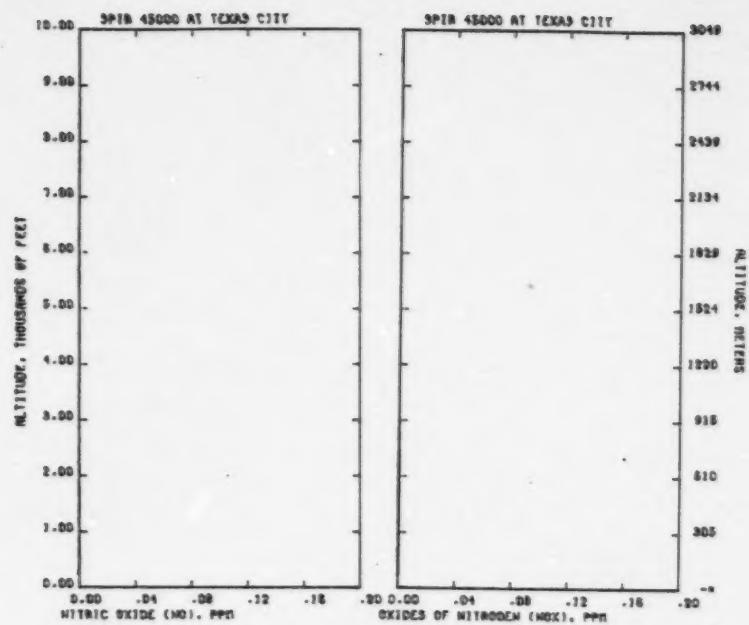


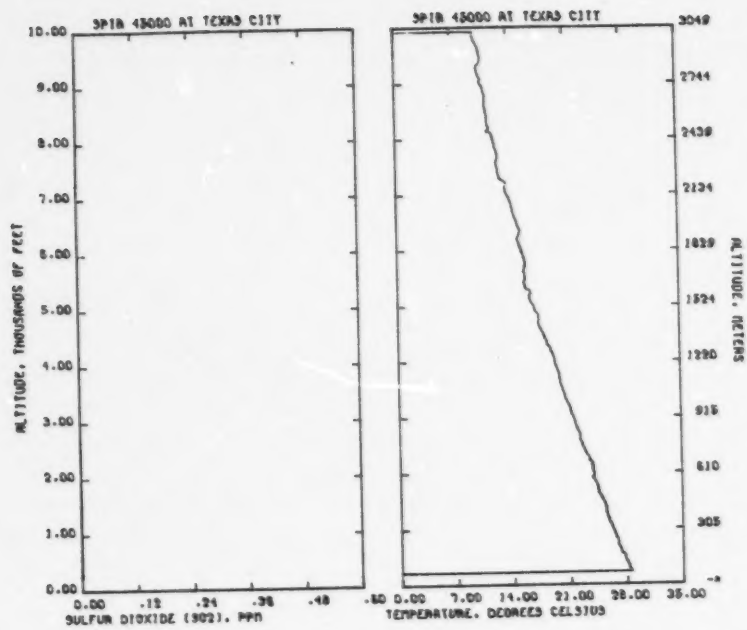


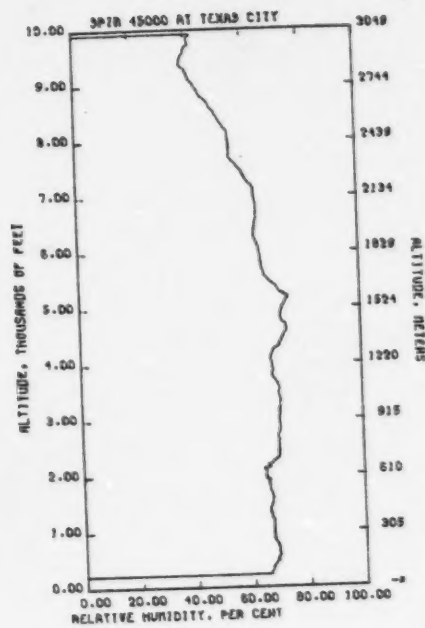
SPIRAL 45000 AT TEXAS CITY 220 TO 9920 FEET
 67 TO 3024 METERS
 7/24/74, 16:48:13 TO 16:20:33, DISTANCE= 9700 FEET
 2957 METERS











APPENDIX B

DATA FOR AIRBORNE HYDROCARBON BAG SAMPLES

TABLE B-1. DATA FOR AMBIENT HYDROCARBON BAG SAMPLES COLLECTED BY AIRCRAFT (CONCENTRATIONS ARE IN PARTS-PER-BILLION OF COMPOUND)

Sample Site	Date	Time, LST	Altitude, m., MSL	Ethylene		Propane +		Vinyl Chloride	Iso-butane
				Acetylene	Ethane	Propylene	Ethane		
Traverse J+D	7/18/74	1607	305	158.8	--	6.6	--	--	--
Traverse J+D	7/18/74	1637	914	119.1	--	8.3	--	--	--
Traverse Hobby-Dyers	7/20/74	1347	305	40.1	10.8	5.7	--	--	7.8
"	7/20/74	1415	1219	45.4	7.9	4.4	--	--	--
Traverse Clear Lake-Flying F	7/20/74	1450	305	33.5	12.3	9.8	--	--	7.8
"	7/20/74	1521	914	43.7	14.3	14.3	--	--	6.5
"	7/20/74	1535	1219	28.5	10.3	11.0	--	--	--
Traverse M+B	7/20/74	0906	518	21.3	--	--	--	--	--
Traverse Clear Lake-Flying F	7/20/74	1030	305	30	21	17.4	--	--	--
"	7/20/74	1107	609	44.8	--	11.8	--	--	--
Traverse Hobby-Dyers	7/21/74	0645	609	22.4	13.4	12.7	--	--	--
"	7/21/74	0656	914	52.9	11.2	13.8	--	--	19.7
Traverse Clear Lake-Flying F	7/21/74	0742	305	37.5	25.4	15.4	--	--	9.1
"	7/21/74	0758	609	25.0	11.0	9.9	--	--	--
Traverse Texas City I+II	7/24/74	1628	305	13.4	16.2	16.3	--	--	24.1
"	7/24/74	1635	609	17.0	12.7	20.8	--	--	47.1
"	7/24/74	1642	914	14.3	13.6	24.2	12.6	--	9.9
Spiral Texas City Mid I+II	7/24/74	1548	3048+1524	--	--	4.4	--	--	--
"	7/24/74	1548	1524+61	46.3	--	6.1	--	--	--
Spiral Galveston	7/24/74	1443	3048+1524	26.6	--	5.0	--	--	--
"	7/24/74	1443	1524+61	5.5	5.3	5.1	--	--	--

APPENDIX C

AIRBORNE PARTICULATE FILTER SAMPLE ANALYSIS

Description of filter samples collected on 0.8 μm Millipore filters. Samples analyzed by optical microscopy and SEM.

TABLE C-1. RECORD FOR 0.8 μ m MILLIPORE FILTER SAMPLES
COLLECTED BY AIRCRAFT

Date	Filter No.	Time		Altitude MSL	Location of Traverse
		On	Off		
7/20/74	1-1	0828	0837	1000	Sugarland + Weiser S. edge of Addicks Reservoir freeway intersection of Galena Pk
7/20/74	2-1	0904	0915	1700	
7/20/74	3-1	1026	1115	1000 2000 3000	3 passes Clear Lake + Flying F
7/20/74	1-2	1344	1419	1000 2000 3000 4000	4 passes Hobby + Dyersdale
7/20/74	2-2	1442	1543	1000 2000 3000 4000	4 passes Clear Lake + Flying F airport
7/21/74	1	0633	0711	1000 2000 3000 4000	4 passes Hobby + Dyersdale 4 passes Clear Lake + Flying F
7/21/74	2	0736	0840	1000 2000 3000 4000	

(Continued)

TABLE C-1 (Continued)

Date	Filter No.	Time On	Time Off	Altitude MSL	Location of Traverse
7/19/74	1	0927	0938	1000	L+A
7/19/74	2	0947	0958	2500	A+L
7/19/74	3	1001	1011	3500	L+A
7/19/74	4	1014	1024	4500	A+L
7/19/74	5	1031	1047	1000	L+A

OBSERVATIONS FROM SCANNING ELECTRON MICROGRAPHS

Date/ Sample No.	SEM Pix. No.	Mag.	Description
7/19 2	7409	500X	Center of filter showing greatest aluminosilicate mineral deposit (still few particles though)
	7410	3000X	Millipore spheres (slightly burned from electron beam)
	7411	3000X	Millipore spheres (unburned)
7/19 4	7431	10000X	Particle containing CaS (gypsum) needles and aluminosilicate
7/19 5	7406	500X	Dark, carbonaceous deposit
	7405	3000X	Same deposit at higher mag.; rods are calcium and silicon
	7404	10000X	Same at higher mag. showing structure of carbonaceous "skeletons"
	7407	3000X	Another dark deposit (no "skeletons") made up of <0.2µm carbonaceous particles

(Continued)

TABLE C-1 (Continued)

Date/ Sample No.	SEM Pix. No.	Mag.	Description
7/19 5	7408	10000X	Top () portion is lead, bromine; bottom of particle is magnesium, aluminosilicate
7/20 2	7443	3000X	Millipore spheres
	7444	300X	Back scatter electron mode showing aluminosilicates as white and higher atomic no. as bright white
	7445	6000X	Two bright white spots from center of above photo in normal SEM mode - sodium chloride
7/20 3-1	7391	100X	Low mag view of heavy mineral (dark spots are carbonaceous) deposit at center of filter
	7393	3000X	Millipore spheres among mineral deposit
	7392	10000X	Millipore sphere from previous photo (after it was burned by electron beam)
	Spec.		X-ray spectrum of typical aluminosilicate prismatic chip
	7395	1000X	Dark deposit of carbonaceous fine material
	7396	10000X	Area of above at higher mag showing particles are <.1µm in size
	7400	1000X	Area of heavy mineral deposit with a lead, bromine, chlorine particle
	7401	1000X	Same area as above in backscatter showing lead particle in center as bright white
	7399	10000X	Bright white particle from above is lead, bromine and chlorine - normal SEM mode
	7403	3000X	Millipore spheres (~ 3µm)

(Continued)

TABLE C-1 (Continued)

Date/ Sample No.	SEM Pix. No.	Mag.	Description
7/20 1-2	7375	100X	Area at center of filter showing heavy mineral deposit
	7376	1000X	Same area at higher mag
	7379	10000X	Sodium chloride (cubical dark spot) particle with calcium, potassium, iron, aluminosilicate particle attached

POLARIZED LIGHT PHOTOMICROGRAPHS

Sample No.	Date	Description
1-1	7/20/74	Shows relatively heavy deposit of minerals (feldspars and clays)
2-1	7/20/74	Shows minerals and carbonaceous agglomerate
3-1	7/20/74	Shows carbonaceous agglomerate seen in slide 13/49
1-2	7/20/74	Minerals and small carbonaceous deposit
2-2	7/20/74	Low magnification view in reflected light, showing heavy mineral deposit on membrane filter

BEGIN
FIRST
LINE OF
TEXT
HERE

TYPING GUIDE SHEET

CENTER
OF PAGE

TOP OF
IMAGE
AREA

DROPPED
HEAD:
BEGIN
SECTIONS
HERE

APPENDIX D

AIRBORNE PARTICLE SIZE DISTRIBUTION MEASUREMENTS

In Table D-1, first column indicates bag sample number which appears in upper left corner of corresponding plot of particle size distribution.

6-1/2"

9-1/8"

BEGIN
LAST LINE
OF TEXT

3/8"

232

PAGE NUMBER

BOTTOM OF
IMAGE AREA,
OUTSIDE
DIMENSION
FOR TABLES
AND ILLUSTRATIONS

TABLE D-1. INDEX TO AIRBORNE PARTICLE SIZE
DISTRIBUTION MEASUREMENTS

Sample Number	Date	Sampling Time, LST	Site	Altitude, m
1-1	7/22/74	1428-1429	Hobby-Dyer Traverses	1122
1-2	7/22/74	1436-1438	"	1122
1-3	7/22/74	1446-1448	"	1097
1-4	7/22/74	1456-1458	"	1115
1-5	7/22/74	1506-1508	"	1097
1-6	7/22/74	1517-1519	"	1122
1-7	7/22/74	1526-1528	"	1128
1-8	7/22/74	1535-1537	"	1097
1-9	7/23/74	0919-0921	Hobby-Dyer Traverses	1073
1-10	7/23/74	0932-0934	"	1079
1-11	7/23/74	0944-0946	"	1091
1-12	7/23/74	0954-0956	"	1067
2-1	7/24/74	0953	Spiral at Hobby	2133
2-2	7/24/74	0953	"	1829
2-3	7/24/74	0953	"	1524
2-4	7/24/74	0953	"	1219
2-5	7/24/74	0953	"	914
2-6	7/24/74	0953	"	610
2-7	7/24/74	1010	"	305
2-8	7/24/74	1120-1122	Turning Basin	914
2-9	7/24/74	1443	Spiral off Galveston West Beach	3048
2-10	7/24/74	1443	"	2743
2-11	7/24/74	1443	"	2438
2-12	7/24/74	1443	"	2134

(Continued)

TABLE D-1 (Continued)

Sample Number	Date	Sampling Time, LST	Site	Altitude, m
2-13	7/24/74	1443	Spiral Off Galveston West Beach	1829
2-14	7/24/74	1443	"	1524
2-15	7/24/74	1443	"	1219
2-16	7/24/74	1443	"	914
2-17	7/24/74	1443	"	610
2-18	7/24/74	1443	"	305
2-19	7/24/74	1515	"	61
2-20	7/24/74	1521	Traverse I-II, Texas City	914
2-21	7/24/74	1521	"	610
2-22	7/24/74	1535	"	305
2-23	7/24/74	1548	Spiral at Texas City, Mid-point of I-II	3048
2-24	7/24/74	1548	"	2743
2-25	7/24/74	1548	"	2438
2-26	7/24/74	1548	"	2134
2-27	7/24/74	1548	"	1829
2-28	7/24/74	1548	"	1524
2-29	7/24/74	1548	"	1219
2-30	7/24/74	1548	"	914
2-31	7/24/74	1548	"	610
2-32	7/24/74	1548	"	305
2-33	7/24/74	1620	"	61
9-1	7/24/74	0641	Hobby-Dyersdale Traverse	609
9-2	7/24/74	0655	Sinclair Retinery	914
9-3	7/24/74	0706	Intersection East Frwy and No. Loop East	1219

(Continued)

TABLE D-1 (Continued)

Sample Number	Date	Sampling Time, LST	Site	Altitude, m
9-4	7/24/74	0747	Turning Basin	305
9-5	7/24/74	0800	"	914
9-6	7/24/74	0815	"	1219
9-7	7/24/74	0834	San Jacinto Monument	1219
9-8	7/24/74	1101	"	914
9-9	7/24/74	1117	Clear Lake	457
9-10	7/24/74	1137	Shell Chemical	609

